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ECONOMIC GEOLOGY

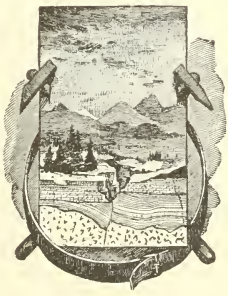
OF

THE AMITY QUADRANGLE

EASTERN WASHINGTON COUNTY PENNSYLVANIA

BY

FREDERICK G. CLAPP



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CONTENTS.

ILLUSTRATIONS.

ECONOMIC GEOLOGY OF THE AMITY QUADRANGLE, EASTERN WASHINGTON COUNTY, PA.

By Frederick G. Clapp.

INTRODUCTION.

The Amity quadrangle lies in the southwest corner of Pennsylvania, and includes a portion of eastern Washington County and two small areas in northern Greene County. It extends from latitude 40° to 40° 15′ and from longitude 80° to 80° 15′, and comprises an area of 228.4 square miles. It is bounded by the following quadrangles: On the north by Carnegie, on the east by Brownsville, on the south by Waynesburg, and on the west by Claysville. The largest town is Washington, which had in 1900 a population of 14,117.

The principal lines of transportation in the region are the Pittsburg, Cincinnati, Chicago and St. Louis division of the Pennsylvania lines and the Pittsburg and Wheeling branch of the Baltimore and Ohio Railroad, both of which pass through Washington. The Waynesburg and Washington Railroad, a part of the Pennsylvania system, is a narrow-gage line running south from Washington to Waynesburg, in Greene County. Along South Branch of Pigeon Creek a branch of the Pennsylvania Railroad has been built as far as the mines at Three and Four.

The main economic interest in this area lies in the facts that it has been the seat of extensive oil and gas development, and that it is almost entirely underlain by at least one valuable seam of bituminous coal. By reference to fig. 4 (p. 89) it will be seen that the quadrangle is located near the center of the north end of the Pittsburg coal field.

The field work on which this report is based was done by the writer and Frank W. De Wolf in July and August, 1904.

COMMERCIAL GEOGRAPHY.

The surface relief of a region is always important in connection with the development of its mineral resources, and in the Amity quadrangle, especially, it is necessary to know something of the topography in order to plan for future economic operations. The amount of relief or difference in altitude between the highest hilltops

and deepest valleys in this quadrangle is moderate, being about 700 feet. A great many creeks and their tributaries dissect the region into hundreds of sharp ridges or knob-like hilltops, with steep slopes extending to the bottoms of ravines which cut up the territory in every direction and make it very rough.

The features of greatest importance in the development of the region are the main valleys. Along them the principal settlements are situated, and they are also generally utilized for through lines of travel, both wagon roads and railroads. For instance, the valley of Chartiers Creek furnishes sites for the towns of Washington and Houston and a direct route for the branch of the Pittsburg, Cincinnati, Chicago and St. Louis Railroad connecting with the city of Pittsburg. The valley of Peters Creek and part of that of Little Chartiers Creek are occupied by the Baltimore and Ohio Railroad for its route between Pittsburg and Wheeling by way of Washington. Tenmile and Little Chartiers creeks and all their larger branches are followed by main wagon roads, and in time they will doubtless be paralleled by railroads. Tenmile Creek affords a specially favorable route for entering the southern part of Washington County by way of Monongahela River.

Of greatest importance are the relations of the topography to the coal industry. The Pittsburg coal bed, which is the most valuable seam in southwestern Pennsylvania, outcrops for several miles along Chartiers and Peters creeks, and here it is possible to mine it by drift and slope with little difficulty, and the small mining settlements of Meadowlands, Anderson, Venetia, and Hackett have sprung up. In portions of the quadrangle where this seam does not outcrop the valleys naturally form the most favorable locations in which to reach it by shafts, and hence operations have been conducted on Pigeon Creek for several years. This creek flows eastward into Monongahela River and forms a convenient route by which a branch of the Pennsylvania Railroad reaches the mines. The valleys of Little Chartiers and Tenmile creeks are suitable for this same purpose.

Within the last twenty years oil and gas have been discovered in paying quantities beneath the Amity quadrangle, and drilling has been conducted on a large scale. In prospecting for oil and gas the valley bottoms are naturally chosen as the first sites for wells, because the expense and time required to drill through several hundred feet of rock in the hills are thereby saved. As development of the field progresses, the position of the oil or gas belt becomes better known, and later wells, being drilled in the most favorable positions for finding the oil without regard to topography, are widely scattered over the hills. Hence, it is apparent that the topography has very little practical effect on the oil and gas industry. The valley of Chartiers Creek, between Meadowlands and Houston, is the site of many large

oil tanks, in which oil from the Washington and Greene county fields is stored. Pipe lines, however, follow both valleys and uplands.

STRATIGRAPHY.

GENERAL STATEMENT.

With the exception of a few comparatively recent deposits in the valleys, the rocks exposed at the surface of the quadrangle are all of Carboniferous age. They belong chiefly to the Monongahela, Washington, and Greene formations, but the Conemaugh reaches the surface in two small patches. The formations which do not outcrop, but which are penetrated by deep wells, include, from the top downward, the Conemaugh, Allegheny, Pottsville, Mauch Chunk, and Pocono formations of the Carboniferous system, and part of the Chemung formation of the Devonian system. Below the Chemung lie thousands of feet of buried strata which have never been reached by the drill in this territory. The general relations of the various beds are shown for the formations which outcrop in the columnar section (Pl. I, in pocket), and for those which do not outcrop in fig. 1 (p. 20).

Although the general relations of the beds are fairly constant, there are considerable variations in details in different parts of the area. Sections a number of miles apart, and even those within a short distance of each other, are likely to differ somewhat in the character and thickness of the various beds. This is especially true of the formations which do not outcrop, as reported in well sections. Over widely extended regions, however, uniform conditions prevailed and sedimentation resulted in strata without much variation at the same horizon. Such horizons serve useful purposes in geologic correlation, and are frequently of economic importance. The Pittsburg coal, the Waynesburg sandstone, the Upper Washington limestone, the Salt sand and the Big lime are examples of strata that are persistent over wide areas. The geologic map of the Amity quadrangle is shown in Pl. I., in pocket.

SURFACE ROCKS.

From the highest to the lowest exposed horizon in this quadrangle the vertical thickness of the strata is about 1,200 feet, the highest point stratigraphically being in the hills in Morris Township, Greene County. The rocks are chiefly sandstones, limestones, and shales, but in the Monongahela and Washington formations several valuable coal beds occur.

CARBONIFEROUS SYSTEM.

ROCKS ABOVE THE WAYNESBURG COAL (DUNKARD GROUP OR PERMIAN SERIES).

THE GROUP AS A WHOLE.

Definition.—The Dunkard group, known in a broader geologic sense as the Permian series, includes all rocks from the top of the Waynes-

burg coal up to the uppermost beds in the Appalachian basin. The rocks were formerly known as the Upper Barren Measures, for the reason that with rare exceptions they do not carry workable coal beds, and they lie higher up in the strata than the Lower Barren Measures.

Character and thickness.—In the Amity quadrangle the greatest thickness of the Dunkard beds is about 750 feet, in Morris Township, Greene County, in the extreme southwest corner of the quadrangle. The beds of this group dip toward the southwest and reach their maximum depth below the surface somewhere in the vicinity of the headwaters of Dunkard Creek, near the boundary between Pennsylvania and West Virginia. In that region some of the hills reach altitudes of over 1,100 feet above the base of the group.

These rocks vary greatly in different regions. In general they consist of shales and shaly sandstones, but a few more or less persistent beds of rather massive sandstone are known, and in the lower portion of the group there are several important limestones. This portion also contains a number of coals, but they are usually of little economic value. In Greene County the Dunkard group carries many beds of red shale. These increase in importance toward the southwest and are most prominent in West Virginia, but toward Washington County they disappear, giving way entirely to the ordinary drab or yellowish shales, traces of which can be seen in some of the highest hills in the southwestern part of the quadrangle.

Division of the group.—The Dunkard group was formerly considered a formation, like the Conemaugh and Monongahela, but in this area the lower portion is much more calcareous than the upper portion, and contains several minor coal beds; it is therefore considered as a distinct formation. The line of division is the top of the Upper Washington limestone, the most persistent and most easily recognizable member of the group. The Dunkard beds above this line are known as the Greene formation and those below as the Washington formation, from the respective counties in which they are typically developed.

ROCKS ABOVE THE UPPER WASHINGTON LIMESTONE (GREENE FORMATION).

Character.—In eastern Washington County no good section of the Greene formation has been measured. In his report on the Greene and Washington district Stevenson[a] gives the following section for Center Township, Greene County, which is of value to show the general nature of the rocks, though there is a wide variation in their intervals and character:

[a] Second Geol. Survey Pennsylvania, Rept. K., 1876, p. 35.

Generalized section of the Greene formation in Greene County.[a]

	Ft.	in.
Concealed	80	
Limestone (XIV)	Fragments.	
Shale, reddish	80	
Limestone (XIII)	4	
Sandstone	50	
Limestone (XII)	10	
Sandstone and shale	80	
Limestone (XI)	2	6
Shale, argillaceous	12	
Sandstone	30	
Coal, Nineveh	*1*	*8*
Sandstone	36	
Shale, bituminous	1	
Limestone (X)	2	6
Sandstone, shaly, massive (Fish Creek)	100	
Coal, Dunkard	*1*	*6*
Limestone (IXb)	3	
Sandstone and shale	30	
Limestone (IXa)	6–15	
Shale, sandy	70	
Limestone (VIII)	2–5	
Coal	*1*	*8*
Sandstone	19–30	
Limestone (VII)	2	6
Sandstone	31	
Shale and iron ore	10	
Limestone, Upper Washington (VI)		

In the Amity quadrangle only one coal in this formation, the Tenmile, has been opened at one or two points. Several limestones are distributed through the formation, but the Prosperity limestone, from 100 to 180 feet above the Upper Washington, is the only one which seems to be at all important.

Distribution.—In this quadrangle the rocks of the Greene formation reach a maximum thickness of about 400 feet in Morris Township, Greene County, and are best developed in the southern and western parts of the quadrangle. On the highlands along the boundary of Greene County, south of Tenmile Creek the formation is continuous, having a thickness of 200 to 400 feet, as far east as Bissell. North of Tenmile Creek and west of Bane Creek it is well developed through Morris, South and North Franklin townships nearly to Washington. It forms the greater part of northwestern Amwell and southern South Strabane townships, and in places attains a thickness of over 300 feet. It is well developed as far north as the Baltimore and Ohio Railroad, but beyond appears only in small isolated areas. Throughout West Bethlehem Township it caps many of the higher hills with a local

[a] The numbers in parentheses are designations applied to the various limestones by Stevenson in his report.

thickness of 100 to 150 feet. Patches of it occur as far north as Odell and nearly to Ellsworth. Several knobs in the vicinity of Denningsville are also capped by it.

ROCKS BETWEEN THE TOP OF THE UPPER WASHINGTON LIMESTONE AND THE TOP OF THE WAYNESBURG COAL (WASHINGTON FORMATION).

Character.—The thickness of the Washington formation varies, but in this quadrangle is generally from 300 to 400 feet. The formation contains several easily traceable members, which have been designated by special names. The following generalized section is given by Stevenson[a] and is believed to be a fair average of the extreme development of the formation in this area:

Generalized section of the Washington formation in Washington County.

	Feet.
Limestone, Upper Washington	30
Sandstone	40
Coal	*1*
Sandstone	40
Limestone, Middle Washington	15
Sandstones and shales	60
Limestone	8
Sandstone and shale	20
Shale, bituminous or coal	1
Limestone, Lower Washington	20
Coal, Washington	*10*
Sandstone, laminated	12
Coal, Little Washington	*1*
Shale	6
Limestone	20
Coal, Waynesburg "B"	*1*
Sandstone	30
Limestone	8
Coal, Waynesburg "A"	*2*
Sandstone, Waynesburg	60

Stevenson[b] also gives a partial section of the Washington formation on Cemetery Hill, in the southern part of Washington, as follows:

Section on Cemetery Hill, Washington.

	Feet.
Limestone, Upper Washington	30
Concealed	50
Coal	*Blossom.*
Imperfectly exposed	80
Limestone, Lower Washington	12
Coal, Washington	7
Clay	4
Sandstone	9
Concealed	10
Limestone	2

[a] Second Geol. Survey Pennsylvania, Rept. K, 1876, p. 44. [b] Op. cit., p. 248.

Distribution.—The rocks of this formation cover a larger area in this quadrangle than those of any other. They occupy the surface of nearly all the central portion, the exceptions being patches of the Greene formation which cap the hills along the Waynesburg and Nineveh synclines. The formation also outcrops along the main branches of Tenmile Creek and up its tributary valleys on the north. On the eastern and northern borders of the quadrangle it forms the hilltops and crests of the ridges above the Monongahela formation.

PENNSYLVANIAN SERIES.

ROCKS BETWEEN THE TOP OF THE WAYNESBURG COAL AND THE BOTTOM OF THE PITTSBURG COAL (MONONGAHELA FORMATION).

Definition.—The Monongahela formation extends downward from the top of the Waynesburg coal to the bottom of the Pittsburg coal, and in this quadrangle varies from 280 to 360 feet in thickness. In the reports of the Second Geological Survey of Pennsylvania it is known as the Upper Productive Measures, to distinguish it from a similar productive formation much lower in the series.

Character and thickness.—The formation consists predominantly of limestones, but also contains shales, occasional sandstones, and at least three valuable beds of coal. The best recorded section in Washington County was measured by I. C. White,[a] near West Brownsville, and is as follows:

Section of Monongahela formation near West Brownsville.

	Ft.	in.	Ft.	in.
Coal, Waynesburg:				
Coal		10		
Clay		3	3	7
Coal	2	6		
Shale and sandstone			45	
Shale, bituminous, Little Waynesburg coal			1	6
Limestone, Waynesburg			10	
Sandstone, shaly			40	
Coal, Uniontown			3	
Shale and sandstone			28	
Limestone, with thin shale			88	
Coal, Sewickley			*Blossom.*	
Sandstone, shaly			32	
Limestone			30	
Shale			20	
Coal, Redstone			1	
Sandstone and shale			45	
Coal, Pittsburg, roof:				
Coal		3		
Clay		3		
Coal	1		2	6
Clay	1			
Coal, Pittsburg, main bench			7	
			368	7

[a] Bull. U. S. Geol. Survey No. 65, 1891, p. 45.

On the Moses Smith farm, in Amwell Township, one-fourth mile northwest of Bissell, a diamond-drill hole was once sunk to the Pittsburg coal, and the record shows a good section of the Monongahela and part of the Washington formation. This is the best detailed section of the rocks available, and is as follows:

Record of diamond-drill hole near Bissell.

	Thickness.		Depth.	
	Ft.	*in.*	*Ft.*	*in.*
Washington formation	154		154	
Monongahela formation:				
Coal, Waynesburg	*6*		*160*	
Sandstone	14		174	
Limestone (Waynesburg[a])	16		.....	
Shale, blue	1		191	
Limestone	6		197	
Shale, blue	12		209	
Shale, sandy	20		229	
Limestone	5		234	
Shale, light	15		249	
Limestone	7		256	
Shale, light (Benwood limestone)	10		266	
Sandstone	16		282	
Limestone	2		284	
Shale, light	5		289	
Limestone	9		298	
Shale, light	7		305	
Limestone	39		344	
Shale, gray	4		348	
Shale, sandy	8		356	
Sandstone, gray	9		365	
Shale, light	4		369	
Shale, dark, sandy	27		396	
Limestone (Fishpot)	32		428	
Shale, light	4		432	
Limestone	4		436	
Shale, light	9		445	
Shale, sandy	19		464	
Sandstone, gray	7		471	
Slate, black	2		473	
Slate, black	1	2	474	2
Coal	*1*	*4*		
Slate, black		4		
Coal		*4*		
Slate, black	1	4		
Fire clay (Pittsburg coal)		5	486	3
Slate, black		9		
Coal		*6*		
Slate	1	3		
Coal	*5*	*10*		
Slate, bottom		11	487	2
Limestone.				

[a] Identifications in parentheses are supplied by the writer.

A section was once exposed in a shaft sunk to the Pittsburg coal opposite the Chestnut street station, in Washington.[a] The upper 29 feet 6 inches of this belongs to the Washington formation, and the 8-inch coal is the Waynesburg seam.

Section in old shaft, Washington.

	Ft.	in.
Washington formation	29	6
Monongahela formation:		
Coal (Waynesburg)		*8*
Shale, gray	6	
Sandstone	5	
Limestone and shale (Benwood limestone), etc	170	
Slate, black	12	
Limestone, gray (Fishpot)	13	
Shale, blue	50	
Sandstone (Pittsburg)	15	
Shale	3	
Coal, Pittsburg	*5*	*6*
	280	8

About 1½ miles north of Washington is the old Enterprise shaft, sunk to the Pittsburg coal many years ago.[b] This gives only a partial section of the formation, as the remaining rocks lie above the surface.

Partial section of Monongahela formation in Enterprise shaft, 1½ miles north of Washington.

	Ft.	in.	Ft.	in.
Soil			4	
Limestone			45	
Coal, Sewickley				*4*
Limestone			30	
Shale			45	
Coal, Redstone			*3*	
Sandstone			20	
Shale			1	
Coal, Pittsburg:				
Roof division	2			
Clay	1		*8*	*10*
Lower division	5	10		

The principal evidence of the thickness of the formation is from a number of oil and gas wells which record both the Waynesburg and Pittsburg coals. Although it is necessary to make an allowance of a few feet for inaccuracies of measurement, these indicate that the formation is not at all uniform in thickness. The following is a list of wells giving the measurements between the top of the Waynesburg and the bottom of the Pittsburg coal in various parts of the quadrangle.

[a] Stevenson, J. J., Second Geol. Survey Pennsylvania, Rept. K, 1876, p. 248.
[b] Stevenson, J J., op. cit., p. 240.

Thickness of Monongahela formation in Amity quadrangle.

No. on Pl. I.	Name of well.	Location.	Thickness of Monongahela formation.
3	Baker	Amwell Township	[a]345
	Moses Smith (diamond drill)	do	336
23	N. T. Clark No. 1	Borough of Deemston	339
32	Mrs. A. L. Hawkins No. 3	do	340
34	L. V. Martindale No. 2	do	338
44	J. L. Thompson No. 1	do	348
45	J. L. Thompson No. 2	do	366
46	J. L. Thompson No. 3	do	345
47	J. L. Thompson No. 4	do	347
48	J. L. Thompson No. 5	do	337
54	Blakeley No. 1	East Bethlehem Township	[a]363
14	Mrs. A. L. Hawkins No. 2	Borough of Beallsville	340
15	Eaton Luse heirs No. 1	do	326
56	Bristor Bros., No. 3	Morris Township, Greene County	[a]353
62	Elmas Carey, No. 1	Morris Township, Washington County	320
	Meloy, No. 1	do	321
	J. C. Mounts	North Franklin Township	.....
234	Washington Floral Co	South Strabane Township	352
273	N. T. Clark No. 2	West Bethlehem Township	340
285	J. C. Martin No. 1	do	337
295	Joseph Ross No. 1	do	[a]323
297	John C. Sargent No. 2	do	[a]348
299	Thompson & Seaman Coal Co. No. 1	do	350
308	S. F. Scott No. 1	West Pike Run Township	[a]308
	Average thickness		340

[a] In this instance the bottom of the Pittsburg coal is not given; it is estimated as being 8 feet (the average distance) below the top of the bed.

By comparison of these records it will be seen that while the lesser measurements are generally more abundant in the western portion there are also points in West Pike Run and West Bethlehem townships, etc., where the thickness is but little over 300 feet. Thicknesses of 345 feet and 352 feet are reported in western Amwell and in South Strabane townships. In general, however, the Monongahela formation in southwestern Pennsylvania grows thinner toward the northwest. In the northern part of this quadrangle no records are obtainable which report both coals, but from estimates of the interval made by subtracting elevations of the Pittsburg coal, as reported in wells, from those of neighboring outcrops of the Waynesburg coal, the thickness in that region seems to average less than 300 feet.

Distribution.—The formation outcrops mostly near the northern and eastern edges of the territory, but it also reaches the surface for about a mile on Little Tenmile Creek at Lone Pine. In the northwest corner of the quadrangle it covers the entire area west and north of Chartiers Creek, with the exception of a stretch near the main valley, occupied by Conemaugh rocks and Quaternary deposits; and

it occupies a strip over a mile wide on the hillsides southeast of and parallel with the creek. In the valley of Little Chartiers Creek it extends from the edge of the quadrangle as far south as Wylandville and outcrops up the side valleys for 2 or 3 miles. In the northeast corner of the quadrangle nearly all of the area north of the Williamsport pike and east of a line drawn northward along Snipe Run, with the exception of a few hilltops, is covered by rocks of the Monongahela formation. A small area along Peters Creek consists of Conemaugh and Quaternary deposits. The Monongahela formation outcrops on the several branches of Pigeon Creek as far as Emeryand Vanceville, and nearly to Three and Four. It also forms the greater portion of the area southeast of Zollarsville and Spring Hill.

ROCKS WHICH DO NOT OUTCROP.

GENERAL STATEMENT.

Sources of knowledge.—Information concerning the rocks which do not outcrop is derived entirely from the records of deep wells bored for gas and oil, and is, therefore, somewhat imperfect. In many cases records have been carelessly kept and beds important from a geologic standpoint, such as coals, bands of red rock, or limestones, have been overlooked or not recorded. In many cases only the oil and gas sands have been noted, thus leaving great gaps in the records. The methods of measurement also introduce some errors. While measurements to the principal oil and gas sands are frequently made by steel line, and are accurate, the depths and thicknesses of the various beds are generally determined by counting the turns of the cable on the shaft of the bull wheel, and errors may easily occur. In deep wells the stretching of the cable may cause an error of considerable magnitude. The difficulty of identifying rocks by the relative ease with which the drill penetrates them and by the drillings brought up in the sand pump is also likely to be a source of error. To this cause may be due many of the lithologic variations recorded in well sections. It may thus happen that important beds which are not recorded are not really absent, but have been overlooked. In some cases a heavy sandstone in one well might change to a highly arenaceous shale or shaly sandstone in a near-by well, and thus be regarded as "slate" or shale. At best, observations on rocks in deep-well sections must be confined almost wholly to their lithologic character. It is usually impossible to learn anything of the fossils by which the ages of the rocks might be determined.

Thickness.—The greatest thickness of the rocks pierced by the drill in the Amity quadrangle is in the Mrs. A. L. Hawkins No. 1 well (31[a]), 1.2 miles southwest of Beallsville. The total depth of this

[a] Numbers in parentheses refer to locations of wells on the map (Pl. I, in pocket) and records given in the table, pp. 70–87.

well is 3,611 feet, or 3,186 feet below the Pittsburg coal. As the lowest exposed horizon in the quadrangle is only a few feet below this coal, the thickness of the nonexposed rocks in the well is about 3,150 feet. Most of the wells in that part of the quadrangle average from 2,500 to 3,100 feet in depth. In the northwestern part they are shallower, averaging not more than 2,300 to 2,900 feet. In neighboring portions of Pennsylvania several deeper wells have been drilled. The deepest of these is a well 12 miles southeast of Pittsburg, which penetrated to a depth of 5,575 feet and is the deepest well in the United States. It started 130 feet below the Pittsburg coal. A very deep well has also been drilled near McCracken, in the western part of Greene County.

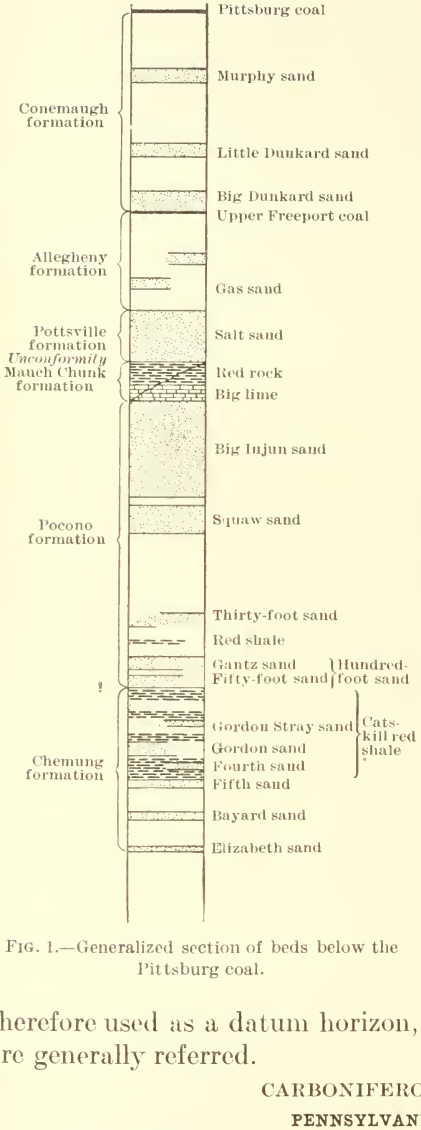


FIG. 1.—Generalized section of beds below the Pittsburg coal.

Datum horizon.—The Pittsburg coal, underlying nearly the entire quadrangle, is the most persistent and most easily identifiable horizon in southwestern Pennsylvania, and is always recognized by well drillers, who make their calculations of the depth to underlying oil and gas sands with reference to it. In this report this coal is therefore used as a datum horizon, to which the depths of other beds are generally referred.

CARBONIFEROUS SYSTEM.

PENNSYLVANIAN SERIES.

ROCKS BETWEEN THE PITTSBURG AND UPPER FREEPORT COALS (CONEMAUGH FORMATION).

Definition.—The rocks known as the Conemaugh formation comprise all those included between the Pittsburg coal at the top and the Upper Freeport coal at the base, both coals being excluded from the formation. In the reports of the Second Geological Survey these rocks were called the Lower Barren Measures.

Thickness.—The thickness of the Conemaugh formation in Pennsylvania varies from 500 to over 700 feet. In this quadrangle it is

known only from well records, and as in the great majority of cases no coal has been recorded below the Pittsburg, not many data are at hand by which to judge the intervals. A few records, however, report the "Connellsville" coal, which is believed to be equivalent to the Upper Freeport bed of the Allegheny Valley. The C. M. Reed well, in North Strabane Township, reports the interval as 600 feet from the top of the Pittsburg to the top of the Freeport. The Reed well (265), in the borough of Washington, records the same interval as 595 feet. If 8 feet is allowed for the probable thickness of the Pittsburg coal, the thickness of the Conemaugh in the two wells is 592 and 587 feet, respectively. A number of wells in the gas field between Zollarsville and Beallsville report the Freeport coal, and the computed intervals are given under the heading "Coal" (pp. 88–117).

Character.—The Conemaugh formation consists principally of alternating shale, sandstone, and sandy shale, although thin limestones and occasional coals are known to occur in it. In many places in southwestern Pennsylvania it contains a number of beds of red shale of variable thickness. These do not occur at any regular horizon, but lie usually in the upper 400 feet of the formation. The Murphy and Little and Big Dunkard sands of the drillers, corresponding, respectively, to the Morgantown, Saltsburg, and Mahoning sandstones on the surface, are in this formation. Probably the most detailed section of the Conemaugh in the Amity quadrangle is that recorded in the Matilda Davis No. 2 well (29), in the borough of Deemston. The section is as follows:

Section of Conemaugh formation in Matilda Davis No. 2 well, Deemston Township.

	Feet.
Coal, Pittsburg.	
Lime	45
Slate	20
Lime	35
Slate	13
Lime	25
Red rock	10
Lime shells[a]	45
Slate	10
Lime	13
Slate	5
Lime	15
Sand	8
Lime	25
Sand	25
Lime	8
Red rock	31
Lime	12

[a] Almost all deep-well records contain frequent reports of such occurrences as "slate and shells," "sand and shells," or simply "shells." The "shells" referred to are not fossil shells of organisms, as in the ordinary sense of the word, but consist of alternating thin layers ("shelly layers") of shale or sandstone.

Section of Conemaugh formation in Matilda Davis No. 2 well, etc.—Continued.

	Feet.
Slate	60
Lime	5
Sand	43
Slate	12
Lime	50
Slate	7
Lime	31
Slate	35
Lime	9
	597

Coal, Upper Freeport.

The complete record of this well is given graphically in Pl. II. It is probable that this is not strictly accurate, owing to the difference between the drillers' and geologists' interpretation of certain beds. Such possible discrepancies should be kept in mind in studying any record. It is especially probable in this particular case that some of the limestone noted is in reality hard sandstone, because in regions where the Conemaugh formation outcrops it contains only a small proportion of limestone.

On account of the variability of the strata and frequent inaccuracies in drillers' interpretations two sections are given below.

The section of the J. L. Thompson No. 5 well (48) is better than the average.

Section of Conemaugh formation in the J. L. Thompson No. 5 well, borough of Deemston.

	Feet.
Coal, Pittsburg.	
Slate	15
Lime	25
Slate	60
Red rock	10
Slate	40
Lime	30
Slate	20
Sand, Murphy	45
Red rock	60
Lime	30
Red rock	20
Sand, white	40
Slate, black	40
Slate	50
Sand, Dunkard[a]	50
	549

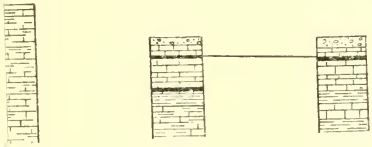
Coal, Upper Freeport.

[a] The word "sand" in all discussions of the solid rock of this area is used in the sense for which it was coined by the well drillers, meaning any sandy stratum.

M CRUM-
o. 1; 1.2
rtheast of
sville;
., 995.
p. 24.)

A. B. CRUMRINE
No. 1; 1 mile east-
northeast of Zol-
larsville; elev.,
865.
(See p. 26.)

MATILDA DAVIS
No. 2; 0.7 mile
east of Zollars-
ville; elev., 840.
(See p. 21.)



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GANTZ, borough of Washington; elev., 1,030. (See p. 23.)

E. T. HYDE, 0.8 mile east of Munntown.

JAS. M. MILLER; 0.6 mile north of Beallsville; elev., 1,075.

A. C. MITCHELL, West Pike Run Township; elev., 1,021. (See pp. 26, 30.)

Lee; 0.6 mile west-southwest of Beallsville, elev., 1,050. (See pp. 29, 31.)

J. L. THOMPSON No. 2; 1.2 miles northwest of Deemston; elev., 1,105.

J. L. THOMPSON No. 3, 1 mile northwest of Deemston, elev., 1,045. (See p. 31.)

J. L. THOMPSON No. 5, 1.2 miles west-northwest of Deemston, elev., 1,030. (See pp. 22, 24, 26.)

WILLIAM CRUMRINE No. 1, 1.2 miles northeast of Zollarsville, elev., 950. (See p. 21.)

A. B. CRUMRINE No. 1, 1 mile east-northeast of Zollarsville; elev., 865. (See p. 26.)

MATILDA DAVIS No. 2, 0.7 mile east of Zollarsville, elev., 840. (See p. 21.)

Dunkard formation.

Monongahela formation.

Conemaugh formation.

Allegheny formation.

Pottsville formation.

Mauch Chunk formation.

Pocono formation.

Chemung formation.

Red shale
Some red shale
Red sandstone
Red limestone
Bedford red shale

1 Waynesburg coal.
2 Sewickley (Mapletown) coal.
3 Pittsburg coal.
4 Upper Freeport coal.
5 Top of Pottsville formation (Salt sand).
6 Top of Mauch Chunk formation
7 Top of Big Injun sand.
8 Bottom of Big Injun sand.
9 Bottom of Squaw sand.
10 Top of Thirty-foot sand.
11 Top of Gantz sand.
12 Top of Fifty-foot sand.
13 Bottom of Fifty-foot sand.
14 Top of Gordon sand.
15 Catskill red beds.
16 Top of Fifth sand.
17 Top of Bayard sand.
18 Top of Elizabeth sand.

Vertical scale
0 100 200 300 400 500 600 700 800 900 1000 feet

SECTIONS OF DEEP WELLS IN THE AMITY QUADRANGLE AND VICINITY.

Records furnished by owners. Geological interpretations by F. G. Clapp. Elevations determined by aneroid barometer.

The original Gantz well at Washington shows a fair section of the Conemaugh, although in this well the base of the formation is rather indefinite.

Section of Conemaugh formation in the Gantz well, Washington.

	Feet.
Coal, Pittsburg.	
Sandstone, soft	10
Slate	12
Shells, hard	2
Slate	10
Sandstone, hard, gray	11
Slate	30
Sandstone, white, soft	10
Slate	51
Sandstone, very hard	80
Slate	10
Limestone	5
Slate	15
Red rock	60
Slate and shells	40
Red rock	25
Slate	32
Red rock	25
Sandstone, white	20
Slate and shells	100
Sandstone, hard, gray	100
	648
Coal and slate.	

As this total is greater than the usual thickness of the Conemaugh formation there is some doubt whether the "coal and slate" occupies exactly the Upper Freeport horizon; but the lower limit of the formation is approximately correct.

In Pl. II are given records of eleven typical wells in the quadrangle, and by comparison of these records the relations of the various beds described and the limits of the formation can be seen. The coals denoting the upper and lower limits of the Conemaugh formation are shown in solid black, sandstone by dotted symbols, slate or shale by continuous or broken parallel lines, limestone by the block symbol, and sandy shale by a combination of lines and dots. The correlation lines other than for coals are represented by dotted lines.

ROCKS BETWEEN THE TOP OF THE UPPER FREEPORT COAL AND THE TOP OF THE POTTSVILLE SANDSTONE (ALLEGHENY FORMATION).

Definition.—Underlying the Conemaugh is the Allegheny formation, which may be defined as extending downward from the top of the Upper Freeport coal to the top of the Pottsville sandstone. This is the formation in which nearly all the workable coal beds in the lower part of the Pennsylvanian series occur. It was for a long time known

by the name Lower Productive Measures, to distinguish it from the productive formation which lies above the Conemaugh.

Thickness.—Where exposed in western Pennsylvania the Allegheny varies in thickness from 270 to 370 feet, averaging about 300 feet. It is difficult to make any very definite determinations in a region where so few complete well records have been kept; but in general the 300-foot average is believed to hold.

Character.—The Allegheny formation consists of sandstone, shale, coal beds, and occasional thin limestones. In the vicinity of Connellsville and in the Beaver Valley, the nearest points where the formation is exposed, it commonly contains several valuable coal beds.

The general character and sequence of strata are shown by several well sections in the borough of Deemston, as follows:

Section of Allegheny formation in the J. L. Thompson No. 5 well (48), borough of Deemston.

	Feet.
Coal, Upper Freeport	5
Slate	25
Lime (Upper Freeport limestone)	15
Slate	80
Gas sand	45
Slate	25
Slate, black	25
Sand	25
Lime (Vanport limestone?)	15
Slate, black	50
	310

Section of Allegheny formation in the A. B. Crumrine No. 1 well (24), borough of Deemston.

	Feet
Coal, Upper Freeport	4
Slate	4
Lime (Upper Freeport limestone)	30
Slate	20
Sand	38
Slate, white	37
Slate, black	40
Sand	55
Slate	30
Lime (Vanport limestone?)	20
Slate	29
Sand	25
Lime	5
	317

The limestone bed occurring near the top of these sections is probably the Upper Freeport limestone. The thin limestone 50 to 60 feet above the bottom may be the Vanport. The sandstones of the formation are several in number and variable in their occurrence. Only one of them, the Gas sand, is reported by well drillers. This generally

corresponds with the Kittanning bed of the surface, but sometimes with the Clarion or even with the Freeport sandstone.

POTTSVILLE SANDSTONE, OR SALT SAND (POTTSVILLE FORMATION).

Definition.—The Pottsville formation, frequently known as "the conglomerate," is the lowest in the Pennsylvanian series. It occurs directly beneath the Allegheny formation, and usually lies unconformably on the Mauch Chunk. In some regions, however, it rests directly on the Burgoon or Big Injun sandstone. The Pottsville formation is the Salt sand of well drillers.

Character and thickness.—In portions of Pennsylvania where it is exposed the Pottsville consists of two or more very massive and frequently conglomeratic sandstones, in some places separated by thin shales, carrying fire clay and coal beds. As recorded in wells in the Amity quadrangle, the formation is a sandstone varying from 60 to 170 feet in thickness and is frequently composed of two members, which probably correspond with the Homewood and Connoquenessing sandstones of the Beaver Valley. Between them a bed of shale 10 to 30 feet thick is sometimes reported and is probably equivalent to the Mercer member of other parts of Pennsylvania. Occasionally a record reports limestone in the Pottsville. The formation is a great source of salt water, which is encountered in drilling.

MISSISSIPPIAN SERIES.

ROCKS BETWEEN THE POTTSVILLE ("SALT SAND") AND BURGOON ("BIG INJUN") SANDSTONES (MAUCH CHUNK FORMATION).

Definition.—The Mauch Chunk formation may be defined as the rocks included between the Pottsville formation above and the Burgoon (Big Injun) sandstone below. The lower portion of the formation consists of a thick limestone, known to drillers as the Big lime. This is identical with the Greenbrier limestone, which outcrops on Chestnut Ridge and Laurel Hill to the east and which was called by the Second Geological Survey the Mountain limestone. The Mauch Chunk is frequently spoken of as the Mauch Chunk red shale, but this designation is hardly appropriate, because in addition to the limestone it also contains shale of other colors and, locally, sandstone.

Character and thickness.—The Mauch Chunk formation is variable in this part of Pennsylvania, as may be seen from the accompanying sample sections. In many records uncertainty exists regarding the upper limit of the formation, but in the absence of definite information the top is generally considered as coincident with the bottom of the thick sandstone overlying the red shale. The following records are typical of those in the Zollarsville field and vicinity. The greatest thickness recorded is about 200 feet, in the J. L. Thompson and other wells. From 50 to 90 feet of this is red shale, 50 to 100 feet at the bottom is limestone, and the rest is shale.

Section of Mauch Chunk formation in the A. C. Mitchell well, West Pike Run Township.

	Feet.
Slate	29
Red rock	10
Slate	10
Red rock	15
Lime	11
Slate	15
Little lime	8
Lime, red	17
Lime, white, Big lime	45
	160

Sand, Big Injun.

Section of Mauch Chunk formation in the J. L. Thompson No. 5 well (48), borough of Deemston.

	Feet.
Slate, white	20
Red rock	5
Pink rock	52
Red rock	35
Slate	15
Little lime	10
Slate	10
Big lime	45
	192

Sand, Big Injun.

Section of Mauch Chunk formation in the A. B. Crumrine well (24), borough of Deemston.

	Feet.
Slate	10
Lime	4
Slate	6
Lime	10
Red rock	15
Lime	6
Red rock	24
Slate	3
Lime	12
Slate	18
Little lime	8
Slate	5
Big lime	50
	171

Sand, Big Injun.

These sections show a fair agreement in the character of the formation, though it will be seen that there is considerable variation in the occurrence of the red beds.

No sections from the western and northwestern parts of the quadrangle can be given on account of the extremely indefinite nature of the upper limit and the lack of complete records. In general, the interval between the Salt and Big Injun sands becomes thinner in

that direction. In the Gantz well, for instance, the interval from the Pittsburg coal to the top of the Big Injun sand is only 1,111 feet. On the assumption that 600 feet is the most probable thickness of the Conemaugh, 300 feet of the Allegheny, and 150 feet of the Pottsville, there is left only 61 feet for the Mauch Chunk. According to correlations in Pl. IV (p. 44), the thickness in this well may amount to as much as 107 feet, consisting of 77 feet of black shale and 30 feet of limestone; but even this thickness is much less than that of the formation in other parts of the quadrangle.

Unconformity.—The irregularity in thickness of this formation is prominent throughout western Pennsylvania, and is caused by an unconformity between the Mauch Chunk and Pottsville formations, due to erosion after the deposition of the Mauch Chunk, and preceding that of the Pottsville. Owing to this feature the Mauch Chunk dies out entirely toward the north and west. The thinning is illustrated by many of the well sections in the Burgettstown quadrangle, northwest of the Amity. For instance, in the McKnight No. 3 well, in Chartiers Township, the interval from the top of the Salt sand to the top of the Big Injun is only about 190 feet. In some wells in Smith Township it is as low as 100 feet. Nowhere in this area is red shale reported in the interval. In two Caltergahn wells in Chartiers Township 35 and 103 feet of black shale are reported. In certain wells in the Burgettstown quadrangle this shale is entirely missing, and the Salt sand rests directly upon the Big Injun. One such occurrence has been reported in the northern part of the Amity quadrangle, in the Thomas Templeton No. 1 well (111), at Linden.

Just where the Mauch Chunk formation disappears, whether the black shale between the Salt and Big Injun sands is Mauch Chunk or Pottsville, and whether all reports of the running together of the sands are correct, are questions which at this date can not be definitely answered.

Greenbrier limestone (*Big lime*).—This bed is well developed beneath the greater portion of the quadrangle, but northwest of Washington it seems to die out. A thinning toward the north has also been noticed by Campbell in the Latrobe and other quadrangles. The disappearance of the Greenbrier toward the northwest is entirely independent of the unconformity mentioned above.

From the well sections it will be seen that the limestone is frequently double, and this feature becomes more conspicuous toward the southwest. The upper bed is known as the Little lime and the lower bed as the Big lime, and they are usually separated by a thin, soft shale, which breaks up in a very peculiar manner into small pieces about the size of a slate pencil. The drill sinks rapidly in this shale as it emerges from the hard limestone above, and the shale tends to "cave in" after removal of the drill. The parting is therefore known to the drillers as the Pencil cave.

ROCKS BETWEEN THE GREENBRIER LIMESTONE AND THE CATSKILL RED BEDS (POCONO FORMATION).

General statement.—The Pocono is the lowest formation in the Carboniferous system. Its uppermost member, which corresponds with the Big Injun sand of the drillers (Burgoon sandstone of the Allegheny Front), extends downward 300 to 900 feet, according to different authorities. Considerable doubt exists as to the true position of its base, as there is a strong resemblance between the rocks contained in it and those of the Chemung formation at the top of the Devonian, and even where they outcrop it is difficult to draw a definite line of separation between them. Such a boundary can be accurately defined only on the evidence of fossils, and in a region where the only information comes from well sections no fossils are known. The weight of evidence in regard to the position of this boundary seems to be in favor of the lowest limit (over 800 feet), and in this report it is drawn provisionally at the top of a group of red shales just below the base of the Fifty-foot sand.[a]

Character and thickness.—If the boundary as just defined is correct, the average thickness of the Pocono formation in the wells where its red-shale base can be determined is 875 feet. One of the best sections of the formation is that of the J. L. Thompson No. 4 well (47), given below:

Section of Pocono formation in the J. L. Thompson No. 4 well, borough of Deemston

	Feet
Sand, Big Injun	60
Break	12
Sand, Big Injun, bottom portion	200
Slate	40
Sand, Squaw	130
Slate and shells	130
Sand, Thirty-foot	60
Red rock (Bedford?)	10
Slate and shells	50
Sand, Gantz	20
Slate	20
Fifty-foot sand	25
Slate and shells	15
Sand	20
Slate and sand shells	40
Sand	10
Slate and shells	20
	862

Directly below the bottom of this section is 10 feet of red rock, which is considered the top of the Devonian system. The Thompson section is fairly typical, but for comparison a second section, that of the Luse well (15) near Beallsville, is given.

[a] For a discussion of the evidence on the position of this boundary, see the Amity folio (No. 144), Geologic Atlas U. S.

Section of Pocono formation in the Luse well near Beallsville.

	Feet.
Sand, Big Injun	290
Slate	20
Slate shells	45
Sand	113
Slate shells	36
Lime	65
Slate	6
Lime	21
Slate	5
Slate shells	14
Hard lime	20
Red rock (Bedford?)	20
Lime	5
Slate	17
Lime	13
Sand, Gantz	30
Slate	21
Sand, Fifty-foot	24
Slate shells	5
Sand	35
Slate and shells	35
	860

This formation contains five principal sandstone horizons—the Big Injun, Squaw, Thirty-foot, Gantz, and Fifty-foot sands. The most important of these geologically is the Big Injun, Mountain, or Manifold sand, as it is variously called. In portions of Pennsylvania where it outcrops it now goes by the name Burgoon sandstone. In Washington County this sandstone averages 250 feet thick and is very persistent. Its top is always in contact with the Greenbrier limestone and is therefore perfectly definite and very convenient as a datum for well drillers. The Gantz and Fifty-foot sands form a very prominent oil horizon, made famous by many old wells in the Washington field. These sands are recognizable in most of the wells. Toward the west, northwest, and southwest they run together and are known as the Hundred-foot sand. The various sands recognized by the drillers are described in detail under the heading "Oil and gas" (pp. 47–59).

Red shale (Bedford?).—In the Burgettstown quadrangle a bed of red shale occurs at many places between the Thirty-foot and Gantz sands and may be a part of the Bedford group of Ohio. On account of the scarcity of complete records in the Amity quadrangle it is known here in only five wells, but when properly recorded it ought to be a fair datum horizon. In the J. M. Miller well (306), in West Pike Run Township, it is 5 feet thick; in the Luse well (15), at Beallsville, 20 feet; in the J. L. Thompson Nos. 3 and 4 wells (46, 47), in the borough of Deemston, 10 feet. In the Gantz well, at Washington, it is recorded as 8 feet of "reddish sand." In parts of western Pennsyl-

vania it amounts to as much as 80 to 120 feet. In places, but not everywhere, it occurs directly below the Thirty-foot sand.

DEVONIAN SYSTEM.

ROCKS BELOW THE TOP OF THE CATSKILL RED BEDS (CHEMUNG FORMATION).

General character.—Throughout the Amity quadrangle the Devonian rocks lie far below the surface. As has been said, the top of the system is very indefinite, but it has been provisionally placed at about the top of the first red shale below the Fifty-foot sand.

The Devonian rocks have been penetrated by wells to a depth of over 1,000 feet. All these rocks are believed to belong to the Chemung formation. The greatest thickness is recorded in the Mrs. A. L. Hawkins No. 1 well (31), near Beallsville. The record of this well is very meager, but a number of shallower wells furnish good sections as deep as the Elizabeth sand. The deepest complete section is on the A. C. Mitchell farm, in West Pike Run Township. The top of the formation here is in considerable doubt, as the red beds are less conspicuous than in some of the neighboring wells, and the section is therefore made to include all beds up to the Fifty-foot sand. To be in harmony with other wells, the top of the Devonian system should here be placed approximately 30 to 50 feet below the bottom of this sand.

Partial section of rocks penetrated by the A. C. Mitchell well, West Pike Run Township.

		Feet.
Sand, Fifty-foot	probably Carboniferous	85
Slate		5
Sand		10
Slate		14
Sand		4
Slate		14
Sand		13
Shells		10
Red rock	Catskill beds	5
Shells		20
Sand, Stray		24
Red rock		21
Sand, Gordon		60
Red rock		55
Shells		30
Slate		10
Sand		15
Slate		5
Sand, Bayard		65
Slate		27
Shells and slate		38
Sand, Elizabeth		6
Slate		169
Shells		167
		872

Two of the best sections of the Devonian are furnished by the J. L. Thompson No. 3 well (46) and the Luse well (15), and these are given for comparison.

Section of Chemung formation in the J. L. Thompson No. 3 well, borough of Deemston.

		Feet.
Red rock	Catskill beds	20
Sand		20
Slate and shells		30
Red rock		10
Slate and shells		55
Red rock		55
Dark slate		10
Red rock		20
Sand		25
Slate and shells		52
Sand, Bayard		15
Slate and shells		69
Sand, Elizabeth		12
Slate		10
		403

Section of Chemung formation in the Luse well, near Beallsville.

		Feet.
Red rock	Catskill beds	15
Slate and shells		40
Red rock		30
Slate and shells		51
Red rock		39
Slate and shells		65
Sand, Fifth		20
Red rock		28
Sand		17
Slate		85
Sand, Bayard		6
Slate		28
Sand		6
Slate		73
		503

Catskill (or sub-Blairsville) beds.—In all the complete records which penetrate the Chemung formation in this quadrangle an interval of 100 to 300 feet near the top of the formation is occupied by two to five beds of red shale, separated by sandstone, shale, and shelly layers. Similar red beds, somewhat thicker but at approximately the same interval (900 to 1,100 feet below the top of the Big Injun) have been noted by M. R. Campbell in many wells in the Latrobe quadrangle and vicinity, and have been named the sub-Blairsville member, for the reason that the wells in which they were reported lie near the town of Blairsville, Indiana County. They are believed to be the westward feathering out of the Catskill formation, which, in eastern Pennsyl-

vania and the Catskill Mountain region, is several hundred feet thick, but which in this region is thinner and is dovetailed into the upper part of the Chemung formation.

The general character of the group containing the red beds can be seen from the well sections given in Pl. II (p. 22). The individual beds vary from 10 to 60 feet in thickness and the total amount of red material in any one section is usually between 75 and 150 feet. In the Latrobe quadrangle the thickness reaches 300 to 400 feet and the member is more of a unit, so that it might almost be termed a formation, but in the direction of the Amity quadrangle it becomes thinner and dovetails into the Chemung formation proper. This method of dying out explains the great variation of the red beds in the different sections and why they do not always occur at the exact top of the formation.

Sandstones.—Between the horizons of these red beds several oil and gas sands, notably the Gordon, Fourth, and Fifth, are frequently reported. The very fact that these sands occur interstratified between red beds, which appear and disappear and sometimes thicken up to the exclusion of the sands, indicates the nonpersistency of most of the sands in this region. The wells penetrating these beds are located in the southeastern part of the quadrangle and nothing is known of the behavior of the beds in other sections. It is considered very probable that toward the northwest they are more broken up, and the Gordon and other sands become more persistent.

Most of the sands in the Pocono formation, commonly recognized by drillers, are shown by records to be encountered rather regularly, and are therefore considered fairly persistent beds. As the drill descends into the underlying rocks, however, it penetrates beds of more and more variable character; and even the most important oil and gas sands are encountered with much less regularity than in the higher formations. These variations are so great that it is now considered probable that the sandstone horizons in the upper part of the Chemung formation are not persistent members underlying the whole area, but are in the nature of lentils, similar to the sandstone lentils of the Allegheny and Conemaugh formations outcropping at the surface. This is in harmony with the character of the Chemung formation in regions where it outcrops.

The principal sands recognized by drillers in the Chemung formation are (from the top downward) the Gordon Stray or Nineveh Thirty-foot, Gordon, Fourth, Fifth, Bayard, and Elizabeth. Of these the Bayard and Elizabeth are the only ones which are at all persistent, as they occur below the variable Catskill beds. A description of the various sands is given in the section on oil and gas (pp. 47–59).

BEDS LOWER THAN THOSE PENETRATED IN THE AMITY QUADRANGLE.

The deepest well in the Amity quadrangle penetrates to a depth of 2,664 feet below the Pittsburg coal, or about 650 to 700 feet below the Elizabeth sand, and but scanty data are given about the beds below the Elizabeth. The nearest point at which anything is known of the underlying beds is at West Elizabeth, Allegheny County, 12 miles southeast of Pittsburg, where a well on the William Bedell farm was drilled to a depth of 5,575 feet. As this is the deepest well in the United States, and as it furnishes a key to the geology beneath Washington County, the record is given here in full, with geologic interpretations. The mouth of the well is 130 feet below the Pittsburg coal.

Record of deep well near West Elizabeth.[a]

Formation.	Record.	Thickness.	Depth.
		Feet.	*Feet.*
	Slate	40	40
	Limestone	10	50
	Shale	80	130
	Slate	105	235
	Sand	30	265
Conemaugh	Slate	40	305
	Coal (Bakerstown?)	*3*	308
	Slate	100	408
	Coal	*2*	410
	Slate	75	485
	Sand	40	525
	Shale	10	535
	Coal (Upper Freeport?)	*2*	537
	Slate	25	562
	Sand	65	627
	Shale	15	642
Allegheny	*Coal (Middle Kittanning?)*	*3*	645
	Limestone	10	655
	Slate	30	685
	Limestone	15	700
	Slate	50	750
	Sand	35	785
	Slate	5	790
Pottsville	Sand, Salt	95	885
	Slate and shells	115	1,000
	Slate	30	1,030
Mauch Chunk	Red rock	20	1,050
	Big lime	50	1,100
	Sand, Big Injun	310	1,410
	Slate and shells	60	1,470
	Sand	15	1,485
	Slate	7	1,492
Pocono	Sand	5	1,497
	Slate	18	1,515
	Sand (Thirty-foot or Berea)	50	1,565
	Slate and shells	60	1,625
	Limestone	10	1,635

[a] White, I. C., West Virginia Geol. Survey, vol. 1 (a), 1904, p. 104.

Record of deep well near West Elizabeth—Continued.

Formation.	Record.	Thickness.	Depth.
		Feet.	*Feet.*
	Slate and shells	100	1,735
	Sand, Gantz?	25	1,760
Pocono (continued)	Slate and shells	20	1,780
	Limestone	10	1,790
	Slate	20	1,810
	Sand	15	1,825
	Slate and shells	45	1,870
	Sand	20	1,890
	Slate	5	1,895
	Sand, Butler Thirty-foot	40	1,935
	Slate	3	1,938
	Sand	18	1,956
	Slate, Stray	30	1,986
	Sand	7	1,993
Catskill	Red rock	3	1,996
	Sand, Gordon, Third, etc	65	2,061
	Red rock	5	2,066
	Sand, Fourth	30	2,096
	Red rock and shells	15	2,111
	Slate and shells	15	2,126
	Sand	5	2,131
	Slate	3	2,134
	Sand	18	2,152
	Red rock and shells	30	2,182
	Sand, Fifth or McDonald	25	2,207
	Red rock and shells	35	2,242
	Slate	10	2,252
	Sand	5	2,257
	Slate and shells	25	2,282
	Sand, Bayard; a little gas	5	2,287
	Sand	10	2,297
	Red rock	25	2,322
	Slate and shells	75	2,397
	Sand, Elizabeth	3	2,400
	Shells	200	2,600
	Slate	150	2,750
	Slate and shells	200	2,950
	Slate	100	3,050
	Limestone and shells	100	3,150
	Sand, Speechley	15	3,165
	Slate	335	3,500
	Sand (Bradford), trace of oil	20	3,520
	Slate and shells	955	4,475
	Slate	23	4,498
	Shells	2	4,500
	Slate	32	4,532
	Shells	13	4,545
	Slate	25	4,570
	Limestone	20	4,590
	Slate	10	4,600
	Sand	30	4,630
	Slate	40	4,670
	Limestone	20	4,690
	Slate	20	4,710

Record of deep well near West Elizabeth—Continued.

Formation.	Record.	Thickness.	Depth.
		Feet.	*Feet.*
	Shells	15	4,725
	Slate	15	4,740
	Slate and shells	10	4,750
	Sand	20	4,770
	Slate	10	4,780
	Limestone	10	4,790
	Slate	20	4,810
	Shells	10	4,820
	Slate	20	4,840
	Limestone	15	4,855
	Slate	20	4,875
	Shells	10	4,885
	Slate	20	4,875
	Shells	10	4,885
	Slate	5	4,890
	Slate and shells	10	4,900
	Slate	15	4,915
	Shells	5	4,920
	Slate	30	4,950
	Shells	5	4,955
	Slate	45	5,000
	Limestone	10	5,010
	Slate	10	5,020
	Slate and shells	10	5,030
	Slate	20	5,050
	Limestone	10	5,060
	Slate	10	5,070
	Slate and shells	10	5,080
	Limestone	5	5,085
	Slate	10	5,095
	Slate and shells	5	5,100
	Slate	30	5,130
	Limestone	10	5,140
	Slate	20	5,160
	Limestone	10	5,170
	Slate	10	5,180
	Limestone	50	5,230
	Slate	30	5,260
	Limestone	10	5,270
	Slate	20	5,290
	Limestone	40	5,330
	Slate	30	5,360
	Limestone	5	5,365
	Slate	15	5,380
	Limestone	10	5,390
	Slate	20	5,410
	Slate and shells	20	5,430
	Slate	15	5,445
	Limestone	5	5,450
	Slate	20	5,470
	Slate and shells	10	5,480
	Slate	95	5,575

The following quotation from White's report is as definite a statement as can be made of the probable correlations for the rocks below the Catskill red beds:

The hole stopped in a dark shale supposed to be the Marcellus, and probably not more than 100 feet above the horizon of the Corniferous limestone, although of course this is a mere inference based upon the fact that in the Conway deep well near Franklin, Pa., the top of the Corniferous was struck at 3,608 feet below the top of the Venango oil sand group, while the drill in the Bedell well stopped at 3,840 feet below the same horizon, and hence the Devonian shales could not extend much deeper. The sand at 3,150 feet has been doubtfully identified with the Speechley horizon, since it underlies the Pittsburg coal by an interval (3,280 feet) 200 feet greater than in Butler County. This, however, would agree with the general southeastward thickening, and is what would be expected. Messrs. Young and Crocker are responsible for the identification with the Bradford horizon of the sand struck at 3,500 feet.

The Warren sand, which, according to Oliphant, lies 350 feet above the Speechley sand, or 500 feet below the top of the Fourth sand, does not appear to have been represented by any distinct sand in this Bedell record. Its horizon belongs near the bottom of the 200 feet of shells, the top of which was struck at 2,400 feet.

GEOLOGIC STRUCTURE.

METHOD OF MAPPING.

Structure contours.—The method of representing the structure or "lay" of the beds is as follows: The top or bottom of some persistent and easily recognizable stratum is selected as a datum surface, and its elevation above sea level determined at as many points as possible. In the Amity quadrangle the horizon selected is the bottom of the Pittsburg coal, the best known and most persistent bed in the region. The structure is shown on the geologic map, Pl. I (pocket), by means of red contour lines. These are drawn at uniform intervals above sea level, and all points on a given contour have the same elevation. In other words, a given structure contour is the line of intersection of the datum surface with a horizontal plane, all points of which have the same elevation above sea level. For instance, the Pittsburg coal at all points along the 650-foot contour has an elevation of 650 feet above sea level. It descends in the direction of the 600-foot contour and rises toward the 700-foot contour.

The intersection of a surface contour with a structure contour of the same elevation marks a point on the outcrop of the Pittsburg coal. At points where the elevation of the surface is greater than that of the coal, the approximate depth of the coal below the surface can readily be found by subtracting the elevation of the structure contour from that of the surface contour. Where the elevation of the surface is less than the corresponding elevation of the coal, the latter has been removed by erosion and the contours simply show the structure. In case the depths of other beds than the Pittsburg are desired, their intervals above or below this must be subtracted or added to the depth of the Pittsburg coal.

To illustrate the use of structure contours, we will suppose that the depth of the Pittsburg coal is desired at the junction of Daniels and Little Daniels runs, in West Bethlehem Township. As can be seen by the map, the elevation of the bottom of the valley at this point is about 890 feet, and the point is very close to the 500-foot structure contour; therefore the Pittsburg coal is calculated to be here about 390 feet (890 – 500) below the surface.

Degree of accuracy.—It should be borne in mind that it is impossible to make structure contours strictly accurate in all parts of the field. Over large areas there are no mines nor wells by which the exact depth of the coal below the surface can be determined. In such instances it is necessary to depend on estimated intervals between the coal and beds which show in outcrop, and as the intervals are in no case constant over any considerable area an error may be introduced which will affect the drawing of the structure contours. In this quadrangle, however, the inaccuracy is probably nowhere very great. By reference to the map, it will be noticed that in certain localities the contours have many waves and turns, while in other parts of the quadrangle they run for miles in long regular curves. This difference is due partly to the greater regularity of the folds in certain regions, but more largely to the greater amount of data that could be secured in such mining districts as Ellsworth, Peters Creek, and Chartiers Creek. In these fields the location of the contours was determined from mine maps showing the elevations of the coal in the areas which have been worked, and in such areas their accuracy is good. In regions where a great many well records are available, as in the Zollarsville field, the structure is likewise more accurate than in portions of the quadrangle that lack such data.

In making the studies for this map and report all roads in the quadrangle have been traversed and the positions of the outcropping rocks noted. These data have been supplemented by the records of as many wells and drill holes in the quadrangle as could be obtained. It is believed, therefore, that the structure of the territory has been determined with a good degree of accuracy.

Limits of error.—In general, the structure-contour interval in a given area is decided by two factors—(1) the steepness of the dip, and (2) the accuracy and abundance of the data available. The Survey is indebted for much valuable information to all the oil and gas operators who have generously furnished well records, and to the coal operators, who have allowed the use of their mine levels. In a region like this, where the dips are all fairly gentle, only the second factor has to be considered. Obviously, it is useless to make the contour interval less than the "limit of error." For example, if over a given area the elevation of the datum horizon was determined to an accuracy of within 50 feet, it would be useless to attempt to draw contours with a

25-foot interval. Moreover, such a representation would be misleading to the reader, who would be led to believe that the elevation at any given point was accurate within 25 feet, which would not be the case. In general, then, the limit of error for any area is not greater than the contour interval.

This point has an important bearing on the structure of the Amity quadrangle as represented by the contours. With the exception of those in the Zollarsville gas field, nearly all the wells in the quadrangle were drilled years ago, at a time when records were generally kept poorly, or not at all, and in some parts of the quadrangle, on account of the unreliability of many records and the absence of wells, no figures are available to determine the depth of the Pittsburg coal, or to check surface tracings and correlations. It must be remembered, also, that the intervals between the surface rocks and the coal are irregular, as explained on page 42. Consequently there are few parts of the quadrangle for which it would be safe to say with certainty that the contours on the Pittsburg coal are accurate enough to justify a 25-foot interval. The closer interval in the Claysville quadrangle, to the west, was made possible by the greater abundance and recency of the drillings, and also by the fact that in that area the more expensive but somewhat more accurate method of leveling with the spirit level to outcrops and wells was used.

STRUCTURE IN DETAIL.

In order to show the relations of the structure in this quadrangle with that in adjacent regions to the east and south, Pl. III has been prepared, giving by contour lines the lay of the Pittsburg coal in the Amity, Brownsville, Rogersville, Waynesburg, and Masontown quadrangles. This plate shows that the general structural features consist of broad anticlines and synclines, which are most prominent along the eastern border of the Appalachian basin and which become gentler in dip and less continuous toward the west.

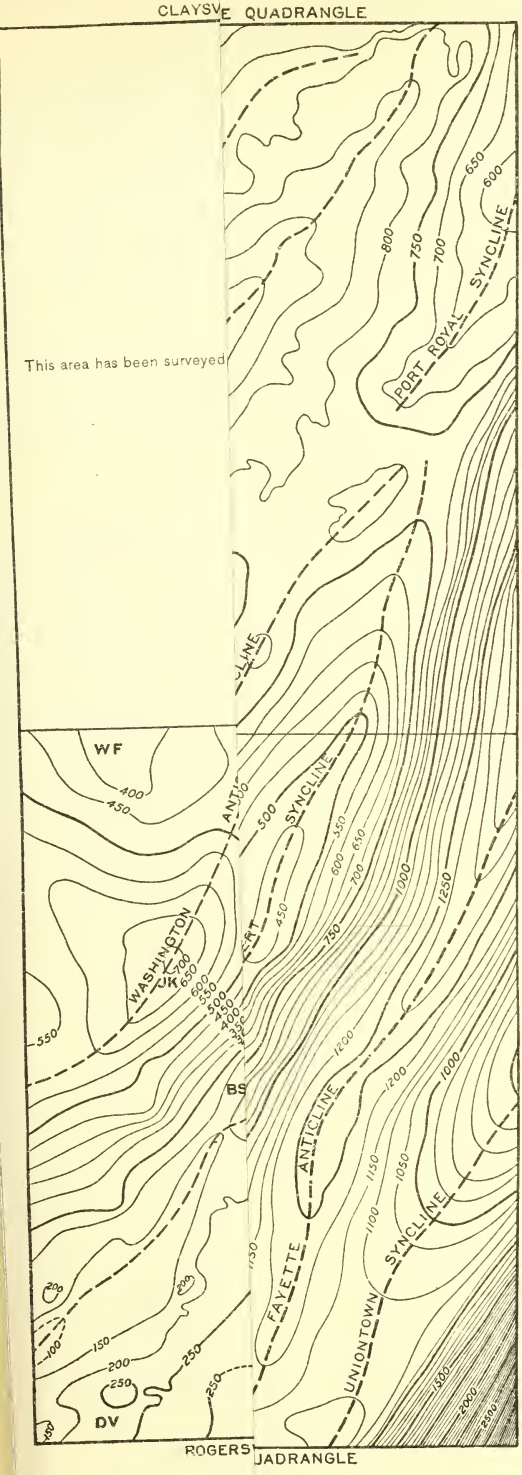
STRUCTURE OF PITTSBURG COAL.

The geologic structure of the Amity quadrangle as represented by the deformation of the Pittsburg coal is shown in Pl. I (pocket). The principal features are three anticlines and two synclines, all trending in a general northeast-southwest direction. These will be described in order from east to west.

BELLEVERNON ANTICLINE.

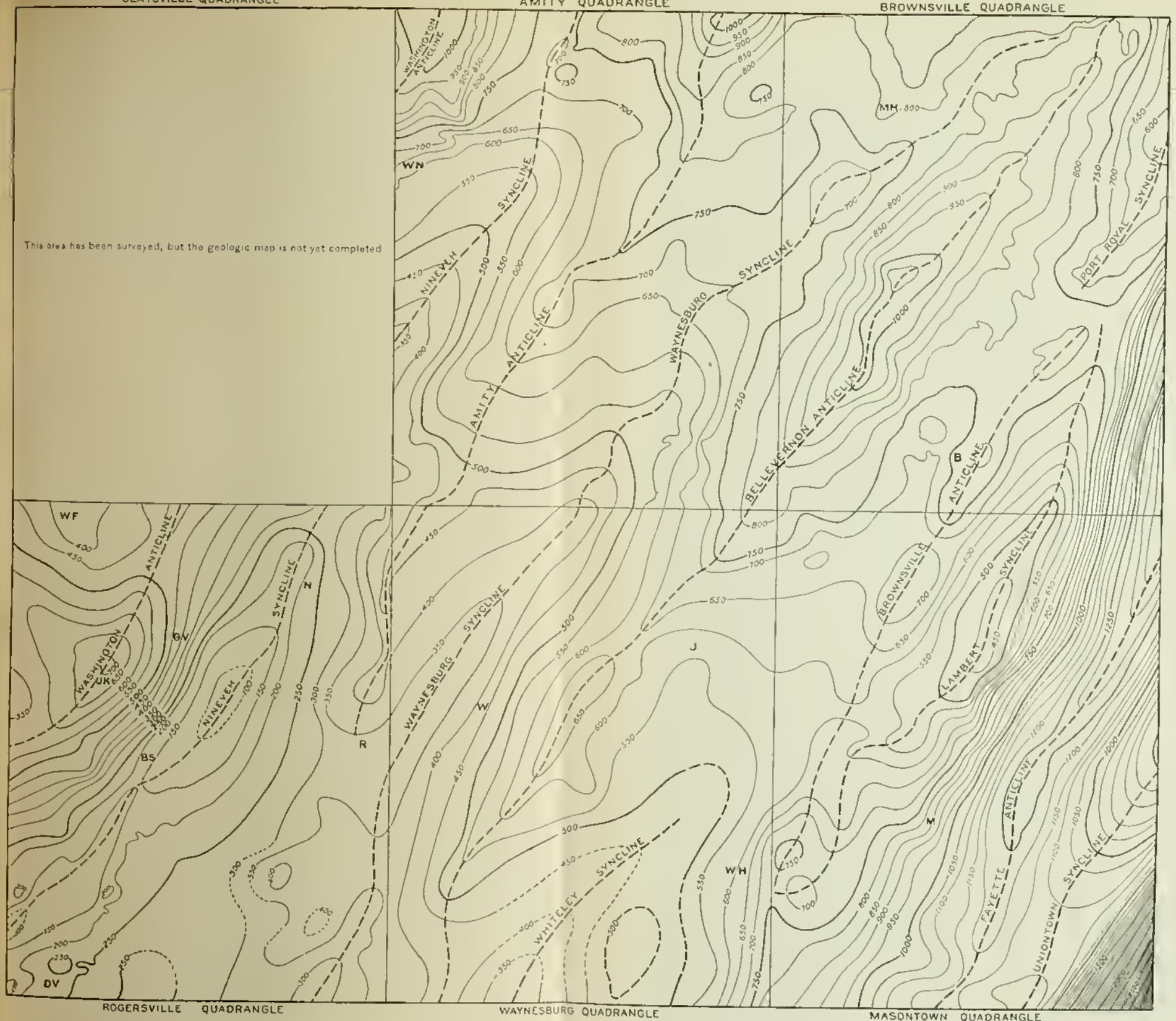
This was called the Waynesburg anticline by J. J. Stevenson in his report published in 1876[a]. He also applied the same name to the syncline lying west of the anticline. When the Brownsville quad-

[a] Second Geol. Survey Pennsylvania, Rept. K.



SKETCH ADRANGLE.

(B = Brownsvill ela; N = Nineveh;



SKETCH MAP SHOWING GEOLOGIC STRUCTURE IN REGION ADJACENT TO AND INCLUDING THE AMITY QUADRANGLE.

(B = Brownsville, BS = Bristoria, DV = Deep Valley, GV = Graysville; J = Jefferson; JK = Jacksonville; M = Masontown; MH = Monongahela; N = Nineveh; R = Rogersville; W = Waynesburg; WF = West Finley; WH = Whiteley; WN = Washington.)

rangle, east of the Amity, was surveyed in 1901 there was some doubt whether the anticline crossing Monongahela River near Bellevernon was continuous with the one passing near Waynesburg, named by Stevenson. On account of this uncertainty and the fact that the term Waynesburg had been applied to two structural features this axis in the Brownsville quadrangle was named by M. R. Campbell[a] the Bellevernon anticline, and this name was continued by R. W. Stone in the Waynesburg quadrangle[b] surveyed a year later.

The anticline crosses the southeast corner of the Amity quadrangle and only about 1½ miles of the axis lies in this territory. The elevation of the Pittsburg coal on its crest is 800 to 840 feet.

WAYNESBURG (PIGEON CREEK) SYNCLINE.

This feature consists of a broad structural trough 10 miles wide lying between the Bellevernon anticline on the east and the Amity anticline on the west. It was named the Waynesburg syncline by Stevenson, but on account of doubt as to its continuity with the syncline having the same relations in the Brownsville quadrangle it was termed by Campbell[c] the Pigeon Creek syncline, after Pigeon Creek, in this county. The present survey demonstrated that the two synclines are one and the same, and since the name Waynesburg had priority the term Pigeon Creek was discarded in its favor.

This syncline is a broad structural basin with generally low dips. The axis enters the quadrangle at Bentleyville and takes a slightly meandering course, averaging about S. 40° W., to the southern edge of the quadrangle. From Bentleyville it follows the valley of Pigeon Creek to Three and Four, where it turns southward and passes half a mile east of Scenery Hill, crossing West Bethlehem Township, and leaves the quadrangle directly south of Bissell.

At the point where the axis of the trough enters the quadrangle from the east the Pittsburg coal is at an elevation of about 750 feet. From this point it descends gradually to the southwest until at the Greene County line the coal is less than 400 feet above sea level. Throughout the basin the average dip is less than 100 feet per mile, except on the eastern side of the axis, between Zollarsville and Beallsville, where for short distances it is as much as 150 feet per mile. In this section the structure is largely determined from well records, and shows several rather peculiar nose-like projections from the flank of the anticline. These are presumably about as represented, as the well records seem to be mostly good, but in all cases due allowance should be made for the possibility of errors in the records. In the

[a] Geologic Atlas U. S., folio 94, U. S. Geol. Survey, 1903.
[b] Idem, folio 121, 1905.
[c] Op. cit.

center of the trough, between Bissell and Scenery Hill, data for determining the depth of the Pittsburg coal are few and it is possible that the basin may be somewhat deeper than it is shown.

AMITY ANTICLINE.

From the Waynesburg syncline the rocks rise gently to the northwest to the crest of the Amity anticline. This was called the Pinhook anticline by Stevenson and White in their reports, the term being taken from a name formerly applied to the village of Lone Pine.[a] The name Pinhook has long since gone out of usage, and since the village of Amity is located almost directly on the axis this name was adopted by Stone in the Waynesburg folio and is here used for the northern extension of the same anticline.

The axis of this anticline crosses the Greene County line near the boundary between Morris and Washington townships. From this point it takes a slight bend or offset to the east, then continues about N. 35° E., passing just east of Amity and through Lone Pine, and crossing the National pike 4 miles southeast of South Strabane postoffice. Beyond this place there is another slight eastward deflection, but within 2 miles the axis veers to the north again and takes a course about N. 30° E., passing west of Vanceville, through Kammerer, and across Nottingham Township to Peters Creek at Anderson. At this place its location was very definitely determined, as it passes through the Blanche mine of the Pittsburg Coal Company.

On the Greene County line the Pittsburg coal is at an elevation of a little over 450 feet, this point being on a sag almost connecting the Waynesburg and Nineveh synclines. South of Tenmile Creek the axis commences to rise at an average rate of less than 50 feet per mile, until 1½ miles south of the National pike it forms an imperfect dome with the Pittsburg coal, as determined by well records, at an elevation of something over 700 feet. Beyond this point the rise does not average more than 20 or 30 feet per mile, except north of Kammerer. A mile south of Peters Creek the axis rises abruptly, bringing the coal from an elevation of less than 900 feet up to 1,040 feet just outside the quadrangle. At its north end this anticline is identical with the Peters Creek anticline described by Stevenson.

On the eastern border of the quadrangle, in Nottingham Township, east of the Amity anticline, a local trough extends into the area for a distance of over 2 miles. It trends west-southwestward, directly toward another small indentation in the anticline. This feature is evidently the cause of the rather sudden deflection of the Amity axis at Mingo Creek, and there seems to be a slight depression of the axis here. There is no true cross syncline, however.

At a number of localities on this anticline the lay of the coal is

[a] Second Geol. Survey Pennsylvania, Rept. K, 1876, p. 27.

rather uncertain, owing to lack of available data. West of Lone Pine and Amity the dip ranges from 100 to 150 feet per mile toward the Nineveh syncline. Farther north it becomes less steep, except between Kammerer and Munntown, where it is estimated to be as much as 100 feet per mile toward the southwest.

NINEVEH SYNCLINE.

This syncline was named by Stevenson in his report on Washington and Green counties from the village of Nineveh, Greene County, near which the axis passes. From that place it runs northeastward and enters the Amity quadrangle west of the village of Sunset. It takes a course averaging N. 42° E. to a point about 2 miles north of South Strabane post-office, whence it trends N. 10° E. nearly to Linden. At this place it makes another slight bend to the east, and leaves the quadrangle just east of Little Chartiers Creek.

The average breadth of this trough in the Amity quadrangle is about 9 miles. Near Sunset, where the axis enters the quadrangle, the elevation of the Pittsburg coal is supposed to be about 350 feet. From this point the rocks rise gently to the northeast as far as Gambles, where the elevation of the coal is a little above 700 feet. Between Gambles and the edge of the quadrangle is a broad, rather flat, structural area, marked by a slight dome and a similar little basin, shown on the map. These are determined by well records. East of Wylandville an arm of the basin extends to the east, as if to cut across the Amity anticline, but dies out before reaching Kammerer. In general, the dips in the Nineveh syncline are very gentle, but on the flank of the Amity anticline, between Amity and Mount Pleasant, they amount in places to 150 feet per mile, and on the Washington anticline they reach an extreme of 250 feet per mile for a short distance northeast of Washington.

WASHINGTON ANTICLINE.

The axis of this anticline enters the Amity quadrangle just south of Chartiers Creek, leaving the quadrangle half a mile west of Houston. The crest is broad and flat, and the coal varies in elevation from 950 feet at the south, to nearly 1,050 feet at the north. To the southeast, it descends rather steeply into the Nineveh syncline. This relatively steep dip is interesting in view of the fact that it is along this slope that the famous Washington oil field is situated. Numerous oil wells in this section have assisted materially in the accurate determination of the structure.

Throughout the quadrangle, all the folds are plunging toward the southwest, in conformity with the general dip toward the center of the Appalachian coal basin.

RELATION OF STRUCTURE OF PITTSBURG COAL TO STRUCTURE OF OTHER BEDS.

LACK OF PARALLELISM BETWEEN BEDS.

In using the contours represented on the map, it should be remembered that few beds are exactly parallel, and hence allowance must be made for the increase and diminution of intervals in various directions. For instance, the Upper Washington limestone, one of the most persistent outcropping beds, varies in this quadrangle from 630 to 710 feet above the Pittsburg coal, and the Waynesburg coal varies from 290 to 360 feet above the same bed. Some of the formations below the surface vary even more than this, as shown in the table of oil and gas sands (pp. 70–87). The causes of variation are twofold—(1) the slight increase and decrease in thickness of various beds due to differences in sedimentation, and (2) the marked variations in the Mauch Chunk formation, owing to an unconformity at its top. The thickness of the Mauch Chunk decreases in general from southeast to northwest.

STRUCTURE OF GANTZ SAND.

It has been said that the Mauch Chunk decreases in thickness from nearly 200 feet at Deemston until it feathers out northwest of Washington. It is even probable that in the northwest corner of the quadrangle, the Big Injun also may be eroded somewhat. Fig. 3 (p. 53) shows graphically the interval between the Pittsburg coal and the Gantz sand, decreasing from 1,960 to 1,800 feet. As determinations of this interval at many points are not based on steel-line measurements, the lines of equal interval may be somewhat in error. As a name for these lines the term isochore is suggested. The word is derived from the Greek *isos* (equal) and *chora* (space), and means lines of equal space, or equal interval. That is, at all points along a given line the interval between the Pittsburg coal and the Gantz sand is the same. In order to determine the elevation of the Gantz sand at any point it is only necessary to find the approximate interval on fig. 3 and subtract it from the figures given for the Pittsburg coal for the same point on the general map.

MINERAL RESOURCES.

PETROLEUM AND NATURAL GAS.

DISTRIBUTION OF OIL AND GAS FIELDS IN THE AMITY QUADRANGLE.

Fig. 2 is a map of western Pennsylvania and portions of southern New York, eastern Ohio, and northern Maryland and West Virginia, illustrating the distribution of oil and gas fields in the northern Appalachians. The oil fields are represented by the dark shade, the gas fields by the lighter shade. The Amity quadrangle,

with its producing areas, is shown near the southwest corner of Pennsylvania.

While oil and gas wells are widely scattered over the territory, the great majority of them are limited to certain groups or fields, in which the oil and gas appear to occur in so-called pools or reservoirs of some extent. The term field, as used in this report, means

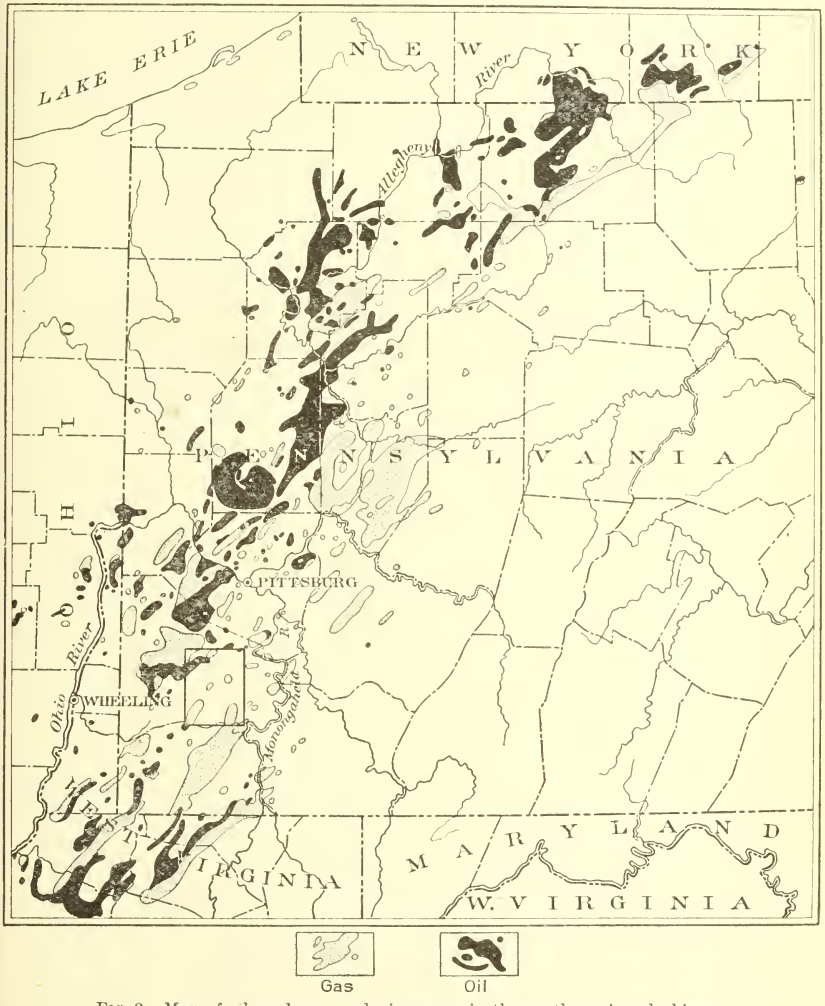


FIG. 2.—Map of oil- and gas-producing areas in the northern Appalachians.

simply a group of producing wells, or wells which have produced in the past, and it is not implied that outside of the field the territory is unproductive. It is probable that in time other sections of the region will be found to contain more or less oil and gas.

In this quadrangle oil is much more limited in its occurrence than gas, and so far as known it occurs almost entirely in one area—the

Washington field. This field extends in a northeast direction from a point near Claysville, in the western part of the county, through the town of Washington and across South and North Strabane townships to the vicinity of Linden. The field includes the Morgan, Willetts, Davis, Taylor, Barre, Smith, Manifold, Munce, Cameron, Thome, Wright, Linn, Rooney, Martin, Wade, Kunz, Le Moyne, and other farms, which were widely known at the time of the oil excitement for their many producing wells.

On the border of Greene County, in the extreme southwest corner of the quadrangle, lies a small oil field, only partially within the area, which is generally known as the Fonner field though sometimes as the Dunn Station field. Portions of this field lie in the Waynesburg, Rogersville, and Claysville quadrangles.

Near the center of Somerset Township small quantities of oil have been produced by a number of wells, and it has been struck in a few wells in West Bethlehem and North and South Franklin townships. A short distance off the quadrangle, northeast of Linden, a new oil field is now being developed.

The principal and only large gas field in the quadrangle is the Zollarsville field, which contains about 70 wells, located mostly in West Bethlehem Township and the borough of Deemston. It has a length of 5 miles and a breadth of about 2 miles. In the Waynesburg quadrangle, south of Zollarsville, there are a few wells in this same belt.

In general, producing gas wells are much more scattering than oil wells and are spread widely over the area. To a few wells in the central part of Amwell Township, between Hackneys and Lone Pine, the name Amity field is often applied. Along this same line to the northeast a small group is encountered west of Odell, in West Bethlehem Township (Ross field), and in central Somerset Township are a number of good gas wells which will be referred to as the Somerset field. Another group, the southward extension of the Cannonsburg field, lies in Chartiers and western North Strabane townships near the quadrangle line. Gas has been found in a number of wells scattered throughout the Washington oil field and in its northern extension near Linden. To the group in this vicinity the term Linden field has been applied.

BRIEF HISTORY OF DEVELOPMENT IN WASHINGTON COUNTY.[a]

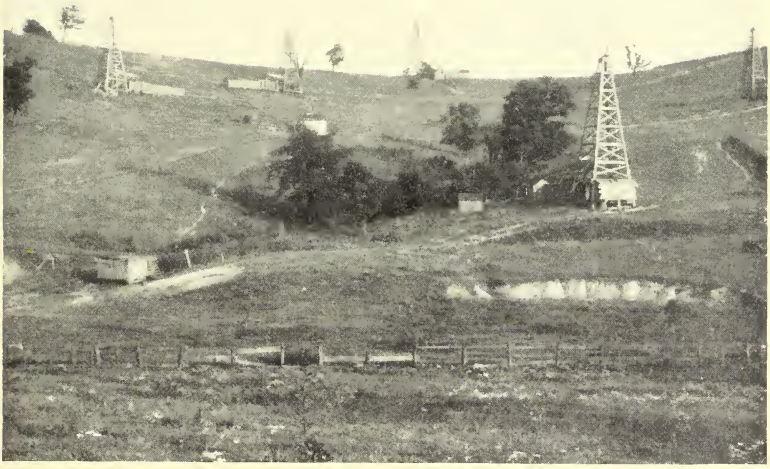
EARLY HISTORY.

The earliest known drilling for oil or gas in Washington County was by the Washington County Eureka Oil Company, organized in

[a] For much of the information contained here the writer is indebted to the staff of the Washington Daily Reporter, who allowed the consultation of its files. Other facts are taken from the Handbook of Petroleum, Derrick Publishing Company, Oil City, 1898.

A. GANTZ WELL, AT WASHINGTON.

First well to produce oil from the Gantz sand.



B. PRESENT APPEARANCE OF OIL OPERATIONS ON WILLETTS FARM, WASHINGTON FIELD.

1861. A shallow well was sunk on the Mannon farm, at West Amity station, on the Waynesburg and Washington Railroad. This well was drilled to a depth of 900 feet and abandoned. About the same time several wells were drilled by other companies at Prosperity, Lone Pine, and in South Strabane Township, but all the workings were abandoned. The Morgan Oil Company came into the region in 1880 and drilled its first wells on the Alexander McGuigan farm, in South Strabane Township. In the second well, at 2,247 feet, the largest flow of gas in the world was struck. It was allowed to go to waste in the air for more than a year before a 6-inch main was finally laid to Pittsburg. At the close of 1885 about five wells had been drilled in the Canonsburg field. By November 1, 1886, 17 wells in that field were supplying gas to Pittsburg.

WASHINGTON FIELD.

March 18, 1884, the People's Light and Heat Company was organized. It commenced drilling on the Hess farm, 1 mile from Washington, in the Claysville quadrangle, and April 30 struck an excellent flow of gas at a depth of 2,068 feet. A few months later another big well was struck on the Harvey property. For some time these two wells supplied the town of Washington with gas.

Later in the year the Citizens Natural Gas Company was organized, and commenced a well on the Gantz mill property, opposite the Chestnut street station of the Pennsylvania lines in Washington. Instead of striking gas, the drill penetrated a sand at 2,191 feet which produced oil. This was December 31, 1884. The Gantz well was the first producing oil well in the county (Pl. IV, *A*), and the producing sand came therefore to be known as the Gantz sand. The Gantz well made two flows, one in January and one in February, 1885, but after this the well was only a "pumper." For some time it was closed down, but was later drilled to the Gordon sand.

Immediately on the circulation of the news that oil had been discovered at Washington great excitement arose among persons interested in oil. The town was at once invaded by a large number of oil experts and other persons, and within three months 21 wells were underway in various parts of the county. Some of these were drilled for gas. In April, 1885, a well was started by the People's Light and Heat Company on the Gordon farm, on the edge of the Claysville quadrangle, north of Washington, and August 22 a sand was encountered at 2,392 feet, from which the oil gushed at a rate of 25 barrels per hour. At that time the Gordon well was the deepest producing oil well in the world, and the sand was called the Gordon sand. Later in the year this well averaged 104 barrels per day for thirty-nine successive days.

With the news that oil had been struck in the Gordon, drilling began

in earnest. Other prominent wells in 1885 were the McNary gas well and the Gordon No. 2. The production of oil in Washington County in that year was 10,500 barrels. January 6, 1886, a well was finished on the Smith farm, which proved to be a gusher with a production of 1,500 barrels per day. March 11, a big pool of oil was struck by a well on the Manifold farm, at a depth of 1,425 feet. This was a peculiar well, as the oil was found in the "Big Injun" sand, several hundred feet nearer the surface than any other strike of oil in the county. The production the first day was estimated at about 700 barrels. The Manifold No. 2 and Willetts No. 11 wells later obtained oil from the same sand.

In April, 1886, the Thayer well came in with 2,000 barrels of oil per day. At the close of May the field contained 16 producing wells and the production was 4,000 barrels per day. In June it had risen to 10,120 barrels. The maximum was in October, when the production amounted to 17,549 barrels per day. After this it declined. The discovery of oil in this field brought the price of petroleum from $1, about a year before, down to 60 cents a barrel at the end of October. Two enormous wells were the Barre 1 and Cameron 1, both in South Strabane Township. The Cameron 1, finished in May, was probably the largest producer in the field. When at its best it yielded from 140 to 175 barrels per hour. In November of the same year it was still producing about 25 barrels per day. Another great producer was the Stewart well. August 17, 1886, this well produced 2,558 barrels. According to the Washington Reporter, the number of producing wells up to September 13, 1886, was 61; and, the average cost of a single well being taken as $8,000, the total cost of the producing wells would be $488,000. There were 25 dry holes in the field, which, with the average cost of each at $7,000, would amount to $175,000. The amount paid in bonuses and purchases was $466,000 and the estimated running expenses $75,000. The total estimated cost was $1,184,700.

For a few years Washington was a great oil camp. Hundreds of wells were drilled in the southern, western, and eastern parts of the town and in the area extending to the northeast as far as Linden. New producers became frequent and the excitement was intense. Nearly all the successful wells were oil wells, though the field has contained a few scattering gas wells. As usual in the rich fields, the greatest production was confined to a very few farms, some of which contained from 10 to 30 wells apiece. Most of these had a rather short life, and the number of producing wells has since steadily decreased until, at the present date, only a few derricks are standing as a reminder of the productiveness of over a decade ago (Pl. IV, *B*). Many of the rich farms have been completely exhausted. In general the sites of the wells have been plowed over or grown up to grass,

but in some cases a pile of débris, the remains of a bull wheel, or a wooden conductor mark the site.

Few wells have been drilled in this part of the field in several years. One or two have recently been drilled to the fifth sand and produce oil from it. In the region southwest of Washington, however, development is still going on. At Meadowlands, in the valley of Chartiers Creek, a pumping station of the Southwest Pennsylvania Pipe Lines is located, and in this valley, between Meadowlands and Houston, are situated about 50 tanks, with an average capacity of 29,350 barrels, in which oil of the southwest district is stored.

The prosperous growth of the town of Washington was largely due to the influx of oil men during the boom and to the productiveness of neighboring farms. Large amounts have been paid in leases to landowners throughout the country. In consequence, many of the farms have a very prosperous appearance and in East Washington handsome residences have been built. Many families, who became well to do at the time of the oil boom, still reside in the town, and a few former operators are now interested in oil fields in other districts.

FONNER FIELD.

Oil was discovered in this field in March, 1897, in a well drilled on the farm of William Fonner. The first well produced 1,800 barrels per day for a short time and then the production declined. A number of wells were drilled in 1898–99 to the Gantz and Fifty-foot sands, which yield the oil.

A number of dry holes were struck in territory immediately adjoining productive wells. In February, 1903, there were 10 wells in the Fonner field, with a daily production of about 50 barrels. The oil is pumped into small tanks and transported by the Southwest Pennsylvania Pipe Lines to the Meadowlands storage tanks.

ZOLLARSVILLE FIELD.

Except in the Fonner field, little drilling for oil has been done in the quadrangle since the eighties, but there has been much prospecting for gas. The largest producing gas field is in the southeastern part of the quadrangle, between Beallsville, Zollarsville, and Deemston. This field contains about 70 wells, and in it new wells are still being drilled. It is operated by the Manufacturers Light and Heat, the Monongahela Gas, the Carnegie, and the Philadelphia companies. In 1904 oil was struck in one or two wells on the western edge of the field.

OIL AND GAS ROCKS.

DESCRIPTION OF THE MAP.

On the geologic map (Pl. I, pocket) three classes of wells are represented, printed in green, red, and black, respectively. Those shown in green are wells which at some time have produced oil; those in red

have produced gas; and those in black were either dry or the product has not been reported. Persons familiar with the region will observe that in the Washington field and in general over the northern and western portions of the quadrangle the data are very incomplete; many wells are omitted, and in others the product is not known. The wells shown on the map include only those of which the exact positions were noted by the geologists in the field, no attempt being made to give any of which the location is doubtful. In portions of the Washington field the wells are bunched so close together that their representation on the general map is impossible. In this field, therefore, only those wells are mapped of which the records have been obtained and published in this report. The remaining wells and those not accurately located are omitted, but the approximate limits of the oil fields are represented on the map by the green shading.

DEPTH OF WELLS.

In the Washington field the wells are only 2,200 to 2,900 feet deep, and this is about the average throughout the quadrangle. In the Zollarsville field the depth is somewhat greater, averaging 2,700 to 3,100 feet. The deepest section in the quadrangle is that of the Mrs. A. L. Hawkins No. 1 well (31) in the borough of Deemston. This well extends 3,611 feet below the surface, or over 3,100 feet below the lowest exposed horizon in the quadrangle.

MODE OF OCCURRENCE OF OIL AND GAS.

The three requisites for the occurrence of oil and gas are, first, a sufficient supply from some source; second, a bed of porous rock in which the oil and gas can accumulate; and third, suitable impervious confining beds—clays or shales—to prevent the escape of the oil and gas into surrounding strata.

OIL AND GAS SANDS.

Drillers' names.—In western Pennsylvania all the oil and gas yet discovered have been produced from beds of sandstone, or "sands," as they are called. The various sands penetrated by the drill have been given common or fanciful names by the drillers, and these names have come into common usage as descriptive of the various beds. Their relations are shown in the following table, which gives the driller's name, the depth above or below the Pittsburg coal, and the geologic formation to which the sand belongs.

Drillers' terms for oil and gas rocks, etc., and their geologic correlations.

[+ indicates above Pittsburg coal; − indicates below Pittsburg coal.]

Formation.	Drillers' name.	Geologists' name.	Approximate maximum thickness in this area.	Average interval to top of bed from Pittsburg coal	Correlation with sands in neighboring fields.
			Feet.	*Feet.*	
Washington	Bluff sand	Waynesburg sandstone.	60	+ 390	
Monongahela	Waynesburg or Pinhook coal.	Waynesburg coal	5	+ 330	
	Mapletown coal	Sewickley coal	6	+ 110	
	Pittsburg coal	Pittsburg coal	10	0	
Conemaugh	Murphy	Morgantown sandstone	100	− 200	
	Little Dunkard sand.	Saltsburg sandstone.	30	− 370	
	Big Dunkard sand.	Mahoning sandstone.	100	− 500	Hurry-up sand.
Allegheny	Connellsville coal	Upper Freeport coal.	6	− 600	
	Gas sand	Kittanning or Clarion sandstone.	70	− 800	
Pottsville	Salt sand	Pottsville sandstone (Homewood + Connoquenessing).	180	− 900	
Mauch Chunk	Red rock	Mauch Chunk red shale	100	−1,050	
	Big lime	Greenbrier limestone.	60	−1,150	
	Big Injun or Manifold sand	Burgoon sandstone	300	−1,200	Mountain sand.
	Squaw sand		130	−1,530	
Pocono	Thirty-foot sand		170	−1,750	Berea or Butler County gas sand.
	Gantz sand		60	−1,900	First sand{Hundred-foot sand.
	Fifty-foot sand		100	−1,950	
	Nineveh Thirty-foot sand.		30	−2,050	Second sand.
	Gordon Stray sand.		30	−2,100	Gray or bowlder sand.
	Gordon sand		50	−2,130	Third sand.
Chemung	Fourth sand		50	2,200	
	Fifth sand		50	2,300	McDonald sand.
	Bayard or Sixth sand.		50	2,400	
	Elizabeth sand		20	2,500	
			30	2,700	Warren First sand.
				2,750	Warren Second sand.

Murphy sand.—The uppermost sand commonly reported by drillers is known in the southeastern part of the quadrangle as the Murphy sand. It occurs in the Conemaugh formation at an interval of 170 to 220 feet below the Pittsburg coal and varies in thickness from 25 to 120 feet. This sand probably corresponds with the Morgantown sandstone, which outcrops at about the same horizon in certain parts of southwestern Pennsylvania and northern West Virginia. It is not productive of gas or oil.

Dunkard sand.—This is the name given to a sand or group of sands

occurring in the Conemaugh formation 480 to 540 feet below the Pittsburg coal and 50 to 100 feet above the Upper Freeport coal.[a] It is frequently recorded as a double sand, in which case the upper and lower divisions are known as Little Dunkard and Big Dunkard, respectively.

The Big Dunkard sand in many places lies almost directly on top of the Upper Freeport coal. It therefore corresponds in position with the Mahoning sandstone, which is one of the most conspicuous sandstone lentils farther north and east in western Pennsylvania. The thickness of the Big Dunkard varies from 30 to 100 feet. Where simply the Dunkard sand is recorded, the Big Dunkard is most commonly referred to, and this is believed to be the more persistent of the two beds. In some cases, however, the sand is thick enough to include both divisions.

The top of the Little Dunkard sand usually occurs at 170 to 240 feet above the Upper Freeport coal, and this sand is therefore considered the equivalent of the Saltsburg sandstone, a lentil which forms a conspicuous surface feature over large areas in the western part of the State. The thickness of the Little Dunkard is generally 20 to 40 feet.

The name of these sands was taken from Dunkard Creek, near the mouth of which an oil pool was discovered in 1861. The Dunkard sand has produced oil in several places, but not in this quadrangle.

Gas sand.—Several sands occur in the Allegheny formation. The principal bed recorded by the drillers is known as the Gas sand and lies near the middle of the formation, 670 to 840 feet below the Pittsburg coal. Although rather variable in position, it generally corresponds, where correctly noted, with the Kittanning sandstone, between the Upper and Lower Kittanning coals. In thickness this sand varies from 15 to 70 feet. A small quantity of gas is occasionally encountered in it.

Salt sand.—The Salt sand corresponds to the Pottsville formation of northern and central Pennsylvania and occurs from 870 to 990 feet below the Pittsburg coal. It varies in thickness from 100 to 170 feet, but generally contains a break of shale near its center. This sand sometimes contains a little gas, but is otherwise unproductive. It is important to the drillers for the reason that it contains a large quantity of salt water.

It should be noted that the Salt sand of this region occurs above the Big Injun, while in Armstrong County the same name is applied to a gas-bearing stratum below the Big Injun.

Big Injun sand.—This is the name given by the drillers to a hard, fine-grained, gray sandstone, which occurs at the top of the Pocono formation, directly below the Big lime. It corresponds with the Burgoon sandstone, which outcrops on the Allegheny Front, and is also

[a] Unless otherwise stated, all intervals in this report are from top to top of the respective beds.

known as the Mountain sand. In Washington County the Big Injun is sometimes called the Manifold sand, for the reason that in a well on the Manifold farm (180), near Washington, oil was found in it.

The Big Injun sand is everywhere present and can be easily recognized by the drillers. In thickness it varies from 250 to over 350 feet. In many places it contains two or three coarse, porous, and, in some cases, pebbly layers, filled with oil, gas, or salt water. These are what the drillers call "pay" streaks. An interesting feature of the sand is a shaly break, which is frequently encountered about one-third of the distance from the top. This break locally amounts to as much as 20 feet in thickness. It has been recorded especially in the J. L. Thompson wells and in a well in Morris Township.

The interval from the Pittsburg coal to the top of the Big Injun sand varies from 1,115 feet in the Culbertson well at Washington, to 1,292 feet in the Burkehammer well near Deemston. In general, it is greater toward the southeast, owing largely to the increased thickness of the Mauch Chunk in that direction. (See pp. 27, 53.) In the vicinity of Washington and in North and South Strabane townships the interval is usually between 1,130 and 1,160 feet. In several wells in North Franklin Township it is reported as 1,200 to 1,225 feet, but to the south, along the western edge of the quadrangle, it diminishes to about 1,140 to 1,190 feet. One record reports as small an interval as 1,075 feet, but the accuracy of this is doubtful.

In the Zollarsville field a large number of measurements of this interval are at hand, and these show a good agreement. Near Zollarsville it varies only between 1,233 and 1,257 feet; near and west of Deemston between 1,200 and 1,286 feet, and southwest of Beallsville between 1,210 and 1,245 feet. Only a few records from Somerset and Nottingham townships are at hand, but in these the figures are 1,196 feet near Ellsworth, 1,205 feet northeast of Vanceville, 1,217 feet north of Bentleyville, 1,156 feet near Kammerer, 1,188 feet midway between Kammerer and Munntown, and about 1,200 feet near Finleyville.

In general, the Big Injun sand is unproductive, but in several places it has locally produced oil. The most important instance of this kind was in the Manifold No. 1 well, drilled in 1886, on the Manifold farm near Washington. This is one of the most remarkable wells in the Washington field on account of its great yield of oil, its long-continued production, and the lack of interference from neighboring wells. Although located in a district which was thoroughly perforated by holes, none of the neighboring wells harmed it, and in none of them, with two or three exceptions, was oil found at this horizon. Of the other wells which produced oil at this horizon, the most important is the Willetts No. 11 close by. The Manifold well flowed about 700 barrels per day. A little gas is reported from this

sand in several wells in West Bethlehem Township and the borough of Deemston.

This sand was named Big Injun by some driller in this county on account of its unusual thickness and hardness.

Squaw sand.—In the northern and eastern portions of the quadrangle a sand commonly occurs 20 to 50 feet below the bottom of the Big Injun. This is known to drillers as the Squaw sand. In many places it is over 100 feet thick, and in the J. L. Thompson wells it reaches 130 feet, but it is irregular and often missing. In the Rogersville quadrangle it has not been recognized.

Thirty-foot sand.—This sand occurs below the Squaw and 450 to 650 feet below the top of the Big Injun sand. The name Thirty-foot means nothing as regards its thickness, for it varies from a knife edge up to 170 feet. The sand is not uniformly present and occurs rather irregularly; but is believed to correspond approximately in its upper and lower limits to the Berea sand of the Burgettstown and Beaver regions, to the Butler gas sand of northern Pennsylvania, and to the Berea grit of Ohio.

The interval from the Pittsburg coal to the top of this sand varies from 1,560 to 1,865 feet. In South Strabane Township the known limits are between 1,560 and 1,630 feet; in the southwest corner of the quadrangle 1,750 and 1,770 feet. In the immediate vicinity of Zollarsville the sand is not recorded, but near Deemston the limiting figures are 1,810 and 1,865 feet. Several wells in this vicinity exhibit a much smaller interval—only 1,720 to 1,740 feet—this being due to a local thickening of the sand. Southwest of Beallsville the interval is usually 1,800 to 1,855 feet, but it varies irregularly, and some measurements are reported which are considerably less. In the Somerset field 1,805 feet is recorded, and near Finleyville about 1,850 feet. The Thirty-foot sand, so far as known, is not productive anywhere in the quadrangle.

The Thirty-foot sand of Washington is not the same as the Thirty-foot of Armstrong County, but probably corresponds closely with what is there known as the Gas, Butler, or Murrysville sand.

Gantz sand.—Next below the Thirty-foot sand is the Gantz, which was named from the farm near Washington on which oil was first produced from this sand. This was the first producing oil well in the county.

The Gantz sand ranges from 60 to 160 feet below the top of the Thirty-foot sand and is a short distance above the Fifty-foot sand. It varies in thickness from 10 to 60 feet. In some wells the Gantz thickens up enough to unite with the Fifty-foot, and in such cases the combined sand is known as the Hundred-foot and is the equivalent of the Hundred-foot sand of Beaver, Butler, and Armstrong counties. It is supposed also to be the same as the First sand of Oil Creek.

The interval from the Gantz sand to the Pittsburg coal seems to be more variable than that of any other persistent sand. Within the quadrangle it varies from 1,790 feet in the Ross well in Chartiers Township to 1,985 feet in one of the J. L. Thompson wells in the Zollarsville field. As with the upper sands, there is a gradual thickening of the interval from northwest to southeast, as shown by figures in the various districts. In Chartiers Township the variation is from 1,790 to 1,821 feet; at Washington, 1,805 to 1,827 feet; in North and

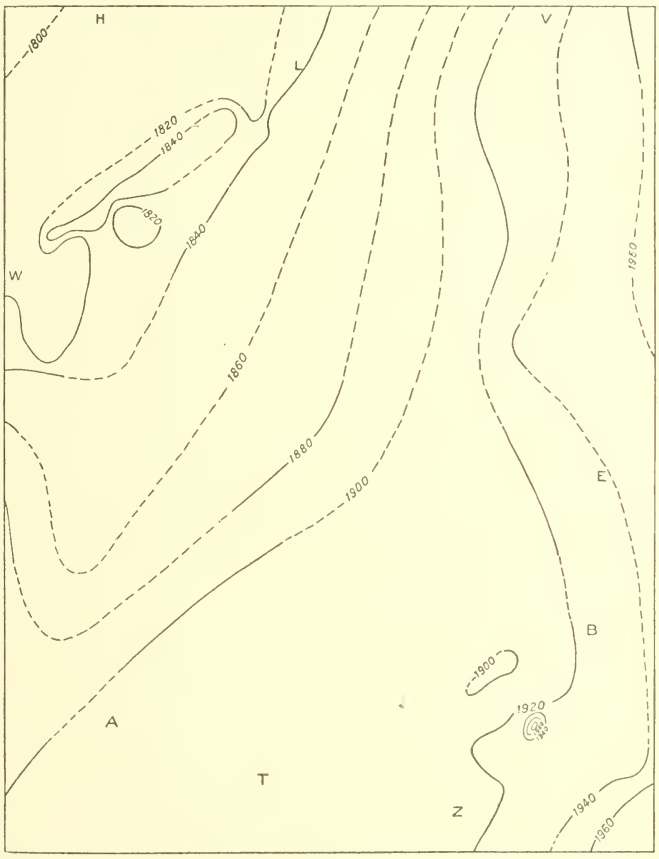


FIG. 3.—Sketch map showing the diminution of interval between the Pittsburg coal and the Gantz sand, corresponding to the unconformity at the top of the Mauch Chunk formation. A, Amity; B, Beallsville; E, Ellsworth; H, Houston; L, Linden; T, Tenmile; V, Venetia; W, Washington; Z, Zollarsville.

South Strabane townships, 1,815 to 1,870; in North and South Franklin townships, 1,820 to 1,880; in the northwestern part of West Bethlehem Township, 1,877 to 1,883; in the Fonner field and vicinity, 1,900 to 1,929; near Zollarsville, 1,890 to 1,955; west of Deemston, 1,910 to 1,985, with two wells as low as 1,820 and 1,845; at Deemston and farther east, 1,910 to 1,970; southwest of Beallsville, 1,886 to 1,933; south of Ellsworth, 1,910; northeast of Vanceville, 1,940;

near Kammerer, 1,907; southeast of Mumntown, 1,925; and at Finleyville, about 1,967 feet. This progressive thickening of the interval toward the south and east is shown by isochore lines in fig. 3, as interpolated from well records. At all points along a given line in this figure the interval from the coal to the Gantz sand is equal, and it thickens or diminishes 20 feet for each line.

The interval from the top of the Big Injun sand to the top of the Gantz varies from 574 to 751 feet, the extremes being, respectively, the well on the Harding lot at Washington and the Gamble well near Kammerer. In single instances considerably greater intervals have been observed, but these are believed to be due either to poor records or to a mistaken correlation of the sands. In North and South Strabane townships the interval varies from 675 to 710 feet; in the borough of Washington, 574 to 670 feet; in the Fonner field, 719 to 748; near Zollarsville, 650 to 722; in the vicinity of Deemston, 630 to 720; and southwest of Beallsville, 650 to 700 feet. In a comparison of these groups of measurements the most noticeable feature is that, unlike the intervals from the coal, they do not show any general thickening toward the southeast. This fact is in harmony with the view that the thickening of the strata is due principally to an unconformity at the top of the Mauch Chunk formation.

The Gantz sand has probably furnished a greater number of producing wells than any other sand in the county. The great majority of the wells in the Washington field obtained their oil from it. In some places the sand has two or three "pay" streaks a few feet apart. An immense quantity of oil has been produced from the Gantz, some of the early gushers having flowed hundreds of barrels the first day. In several cases the production the first twenty-four hours reached 2,000 to 3,000 barrels.

The Gantz sand is also the principal producing sand of the Fonner field, where it furnishes both oil and gas. In this part of the quadrangle, however, the Gantz and Fifty-foot are frequently found in contact, forming the Hundred-foot. The Gantz sand also produces gas in a few wells in the Zollarsville and Somerset fields, and it is the principal gas sand of Chartiers Township in this quadrangle.

Fifty-foot sand.—This is the lower division of the Hundred-foot and has a wide distribution in the Amity quadrangle. Under this name drillers often include the Gantz in wells where the two sands are combined. The Fifty-foot sand itself locally splits into two sands. Its distance from the bottom of the Gantz sand varies up to 80 feet, being greatest toward the southeast. Where distinct from the Gantz, the sand is here and there as much as 100 feet thick, though generally thinner.

The distance from the Pittsburg coal to the Fifty-foot sand varies from 1,807 feet in the Matthew Linn well at Washington to 2,057 feet in the Burkehammer well in the borough of Deemston. This interval

in the Washington field, including North and South Strabane townships and the borough of Washington, varies from 1,817 to 1,930 feet; in the Amity and Fonner fields, from 1,905 to 1,941 feet; in the Zollarsville field, from 1,940 to 2,057 feet. The bottom of the Fifty-foot sand is usually not over 50 feet above the top of the group of red shales which are considered the Catskill beds at the top of the Devonian system. This sand is therefore considered as most probably the lowest sand in the Carboniferous system. (See discussion on p. 28.)

The distribution of oil and gas in the Fifty-foot sand shows a fair agreement with their occurrence in the Gantz, as would naturally be the case where two sands in close association are in places combined. In the Washington field the Fifty-foot sand has furnished many good wells, including some of the great producers. Many of the wells which found oil in both the Gantz and Fifty-foot obtained the greater proportion from the lower of the two sands. The Fonner field has also furnished oil wells from this sand. In this field the Fifty-foot and Gantz sands are generally united.

The Fifty-foot sand has not yet produced a great amount of gas, but in Somerset Township several wells have obtained gas in this sand and it has occasionally been found at this horizon in the Zollarsville field. In the Washington field a large proportion of the oil wells, including most of the enormous producers, have long since ceased to be productive and have been abandoned.

Gordon Stray sand.—Above the Gordon sand and near the top of the red beds a sand is sometimes reported by the name of Gordon Stray. Sands at about this horizon are also frequently called Butler Thirty-foot, Nineveh Thirty-foot, or simply Thirty-foot or Stray. There is considerable doubt whether this horizon should properly be included in the Chemung formation or in the Pocono, but as in a few cases thin red shales have been reported just above it, the Gordon Stray sand is here considered one of the lentils in the Catskill member of the Chemung.

Although not classed as one of the productive sands, the Gordon Stray is frequently known to produce gas, and in the borough of Washington gas has from time to time been found in it. One of these gas wells was that of Matthew Linn, in which the rock pressure amounted to over 600 pounds per square inch.

Gordon sand.—In the vicinity of Washington this is one of the principal oil sands, and occurs near the top of the Venango oil group and of the Third sand horizon of Oil Creek. The name "Gordon" originated from the Gordon farm near Washington, where the sand was first pierced by the drill in August, 1885. In the Gantz well this sand occurs 245 feet below the top of the Gantz sand, and in other wells in that vicinity the interval varies from 240 to 300 feet. It is usually about the first conspicuous sand below the top of the Catskill

red beds. The usual position of the Gordon sand is shown by the Kountz No. 1 well (174) in South Strabane Township. The sand, which is here designated Gordon, was noted by the driller as the "Stray sand," but, to judge from the intervals, this was a mistake.

Partial section of Kountz No. 1 well, South Strabane Township.

		Feet.
Sand, Gantz	Pocono?	104
Slate	Pocono?	81
Red rock	Catskill	10
Sand and slate	Catskill	10
Slate	Catskill	16
Sand (Gordon)	Catskill	60
Slate	Catskill	19
Sand	Catskill	20
Slate	Catskill	3
		323

In the Fonner field, just off the southwest corner of the quadrangle, the William Fonner No. 2 well gives a section which shows a similar relation of beds.

Partial section of William Fonner No. 2 well, Morris Township, Greene County.

		Feet.
Sand, Gantz	Pocono?	29
Slate	Pocono?	2
Sand, Fifty-foot	Pocono?	35
Slate, black	Pocono?	11
Sand, red	Catskill	15
Slate	Catskill	53
Red rock	Catskill	5
Sand shells, gray	Catskill	15
Pencil cave[a]	Catskill	5
Sand, Gordon	Catskill	50
Slate, black	Catskill	80
Sand and shells	Catskill	35
		335

The thickness of the Gordon sand varies from 10 to 50 feet. At Washington and in South Strabane Township it seems to be fairly persistent and has probably been always correctly identified by the drillers. In other parts of the quadrangle, however, its persistency is not so certain. In North Strabane Township it is rarely reported, except in the vicinity of Linden. In the southeast corner of the quadrangle it is frequently recorded, but is just as often missing and is very irregular. Where recorded in this region it sometimes apparently includes the Fourth sand.

The interval from the Pittsburg coal to the Gordon sand in South Strabane Township and Washington varies from 2,051 to 2,125 feet;

[a] The usual "pencil cave" horizon of the drillers occurs in the Mauch Chunk formation several hundred feet nearer the surface.

in Chartiers Township it runs 2,029 to 2,078; in the vicinity of Linden 2,077 to 2,129; in North Franklin, according to the few available records, it is fairly constant at 2,070 to 2,078 feet; at Sunset it is 2,123 feet; in the Fonner field the variation is from 2,080 to 2,095 feet; in the Zollarsville field, from 2,110 to 2,240, with occasional reports as low as 2,047 and 1,979; and southwest of Kammerer the amount is 2,160 feet.

The Gordon sand has locally furnished both oil and gas, but it can not be ranked as one of the principal producers. The original flow of oil from the Gordon well was 25 barrels per hour. As stated above, it is improbable that the Gordon sand is in reality one continuous bed beneath the whole quadrangle.

Fourth sand.—Where present, this sand is dovetailed into the Catskill beds, about 40 to 140 feet below the top of the Gordon. Like the Gordon, it is irregular, and probably not persistent as a definite bed. In thickness it varies from 10 to 50 feet. The distance from the Pittsburg coal is as follows: In South Strabane Township, 2,101 to 2,135 feet; in the vicinity of Linden, 2,138 to 2,160; at Washington, 2,130 to 2,163; in North Franklin Township, 2,121 to 2,165; in the Ross field, 2,102 to 2,130; in the Zollarsville field, 2,211 to 2,350 feet.

In only a few instances has this sand produced gas. The sand has been noted no more frequently than the Gordon, which indicates something of its nonpersistence and variability.

Fifth sand.—The Fifth sand is also within the limits of the Catskill beds; but it seems to be more persistent than either the Stray, Gordon, or Fourth. In general it occurs near the lower limit of the Catskill and in some places has no red shale below it. In one well the Fifth is reported as a "red sand." The position of the sand is 250 to 400 feet below the top of the Gantz, and it is reported in nearly all wells which are deep enough to reach it. In a considerable number of records in the borough of Deemston and in East Bethlehem Township, however, no Fifth sand is mentioned. This sand varies in thickness from 10 to 50 feet.

The interval below the Pittsburg coal varies in North Strabane Township from 2,186 to 2,220 feet; in South Strabane, 2,175 to 2,280; at Washington, 2,174 to 2,201; in North Franklin, 2,181 to 2,207; in South Franklin, 2,208; in the Ross field, 2,180 to 2,181; 2 miles northeast of Lone Pine, 2,205; in the vicinity of Zollarsville, 2,352 to 2,409; west of Deemston, 2,272 to 2,371; near Deemston, 2,327 to 2,359; southwest of Beallsville, 2,272 to 2,336; and north of Bentleyville, 2,300 feet.

With the exception of the Bayard and Elizabeth sands, the Fifth has been one of the most important gas-producing sands of the quadrangle, but most of the wells obtaining gas from it are now abandoned. They were situated in the northern extension of the Wash-

ington oil field in the vicinity of Linden and west of Gambles station. A number of these wells north of Linden occur in the syncline. Just outside of the borough of Washington the Morgan No. 11 well, drilled in 1900, has produced oil from this horizon. In North and South Franklin townships the sand has given a little oil in several wells. Some gas has been produced from this horizon in the Zollarsville and Somerset fields.

Bayard sand.—In the western and northwestern parts of the quadrangle the wells are in general not deep enough to reach the Bayard sand, and nothing is known of it. In Morris Township several wells pass into the Elizabeth without reporting the Bayard, and as few of the deep wells in the Rogersville quadrangle note this sand it may die out in that direction. It is reported in one well in North Franklin Township. In the Deemston field and vicinity a great many wells penetrate the Bayard, which is usually reported 50 to 150 feet below the top of the Fifth. Owing to its position it is frequently called the Sixth sand, but this name has also been applied to the Elizabeth. In thickness it averages about 20 or 30 feet, here and there amounting to as much as 50 feet.

The Bayard sand is reported in numerous wells in the Zollarsville field, where the distance below the Pittsburg coal varies from 2,337 to 2,479 feet. In a well southeast of Munntown it is 2,400 feet, and in North Franklin Township 2,231 feet.

A large part of the gas produced in the Zollarsville field comes from the Bayard sand. In other sections the sand is not important, although beneath a large proportion of the quadrangle it has never yet been penetrated.

Elizabeth sand.—The deepest sand which has yet proved of any importance is the Elizabeth, which lies 50 to 150 feet below the top of the Bayard. It is also sometimes known as the Sixth sand, though this name is more often applied to the Bayard. In general the Elizabeth is supposed to be more persistent than the Bayard, being reported in nearly every well which reaches its horizon. It is, however, one of the thinnest of the sands, rarely exceeding 20 feet, and usually considerably less. In the Waynesburg quadrangle to the south it is not known to exceed 7 feet.

Notwithstanding its great depth, this sand has been penetrated by many wells in the Zollarsville field, where its distance below the coal ranges from 2,470 to 2,530 feet. By comparison with the measurements given for the Bayard sand it will be noticed that the Elizabeth is much more constant. One measurement of 2,588 feet is reported, but this is an exception. The interval is 2,482 feet in a well north of Bentleyville, 2,506 at Lone Pine, and 2,400 in the Fonner field.

In the Zollarsville field the interval from the Elizabeth to the top

of the Gantz sand is 528 to 620 feet, with occasional records as high as 743. The excessive amounts are generally due to indefiniteness in the position of the top of the Gantz sand. In the Fonner field this interval is 500 feet and at Lone Pine 600 feet.

The Elizabeth sand is at present the great gas producer of the Zollarsville field. Gas has also been obtained from it in Somerset Township. Beneath the greater part of the Amity quadrangle this sand has never been penetrated, but it would seem to offer good opportunities for future prospecting. Oil and gas are reported to occur in this sand in one well in North Franklin Township.

Beds below the Elizabeth sand.—In general, the Elizabeth sand may be considered the bottom of the geologic record, but a few wells in the quadrangle have reached greater depths. The Mrs. A. L. Hawkins No. 3 (32), in the borough of Deemston, reports a "Sweet sand" 40 feet below the top of the Elizabeth. The recorded thickness is only 4 feet. In the H. H. Richards No. 1 well (293), in West Bethlehem Township, this sand has the same thickness and occurs 69 feet below the top of the Elizabeth. A number of wells penetrate this horizon without reporting the sand. In the George Thompson No. 1 (309), in West Pike Run Township, a sand 30 feet thick was noted 290 feet below the top of the Bayard, and 101 feet lower the bottom of a bed of "broken shells and slate" is recorded. These beds have not been definitely correlated, but are believed to approach the horizon of the Warren First and Second sands of northern Pennsylvania. In the Mrs. A. L. Hawkins No. 1 well, near Beallsville, beds of a different character occur. Nothing is recorded there in the interval of 747 feet below the top of the Fifty-foot sand, but at that depth—2,264 feet below the Pittsburg coal—there are 48 feet of "sand and lime." Below that the record gives only 474 feet of "slate and shell." This record was evidently considerably generalized by the driller. In only one instance, in the southern part of the Zollarsville field, is gas known to occur below the Elizabeth sand.

PRODUCTION OF OIL AND GAS.

WASHINGTON OIL FIELD.

The principal production of oil in the Washington field was in the years immediately following its discovery in 1885. Throughout the history of the field oil has been obtained mostly from the Gantz and Fifty-foot sands, and all the gushers were from these sands. In the early days the flows from some of the big wells were enormous. Among the noted wells were the William Barre Nos. 1 and 3; William Davis Nos. 1, 2, 3, and 4; Morgan Nos. 5 and 9; Matthew Taylor Nos. 1, 2, 3, and 4; Workman Nos. 1 and 2; the Gordon well; A. M. Smith Nos. 1 and 3; Manifold; Taylor; Willetts Nos. 1, 3, and 5; Munce No.

11; and Cameron No. 1, all of which flowed over 100 barrels in the first twenty-four hours.

Of these, the Davis No. 2 produced 2,200 barrels per day; the Davis No. 4, 1500 barrels during the first twenty-four hours; the A. M. Smith No. 3, 2,800 barrels, and the Matthew Taylor No. 3, 2,300 barrels in the same length of time. The largest well in the field was the Cameron No. 1, which at first produced 50 barrels per day, but after a few days reached 140 to 175 barrels per hour. May 31, 1886, the field contained 16 producing wells, the list of which, according to the Washington Reporter, is as follows:

List of producing wells in Washington field May 31, 1886.

Well.	Owner.	Production per day.
		Barrels.
McGovern	Union Oil Co	28
Taylor	do	722
Lead works	Mulholland, McKeever & Co	12
Do	Caldwell & Marsh	18
Gantz	Citizens Oil and Gas Co	25
Weaver	do	10
Montgomery	M. S. Kinney Bros	7
Gordon, No. 1	People's Light and Heat Co	90
Gordon, No. 2	do	8
Gordon No 4	do	275
Hess No. 2	do	40
Munce Purchase, No. 1	I. Willetts	150
Munce Purchase, No 3	do	725
Munce Purchase, No 5	do	200
Smith, No 1	Belmont Oil Co	536
Cameron, No. 1	do	2,424

Some of the wells, including those on the Davis, Willetts, and neighboring farms, have maintained their production wonderfully, and these farms still have several producing wells. After fifteen years the William Smith No. 3 produced 7 barrels per day. The production of the Washington field for 1887 was estimated at 2,859,344 barrels, or 7,800 barrels per day. For 1888 it was 2,322,189.73 barrels. Most of the old wells have, however, run dry and have been abandoned, and those still existing are gradually disappearing.

Besides the Gantz and Fifty-foot sands the Gordon has yielded oil in a few wells in the Washington field and the Fifth sand in several. The deeper sands have not yet been prospected, but they would seem to offer a field worth testing. As explained on page 51, the Big Injun sand proved productive in the Manifold and Willetts No. 11 wells—hence the name Manifold sand. The pocket of oil in that sand was, however, a very local one.

One characteristic of the Washington field is that it was worked by a great number of small operators. At the time the excitement was at

its height, the Washington Reporter published a list of 125 wells and their owners, in which over 40 different companies and individuals were represented. The more extensive operations were carried on by the Forest Oil Company, People's Light and Heat Company, Willetts Oil Company, Associated Producers Company, Manufacturers Light and Heat Company, Chartiers Oil Company, John McKeown, Pew & Emerson, and the Belmont Oil Company.

In the vicinity of Meadowlands there are about 50 oil tanks, having an average capacity of about 29,350 barrels each, a total of 1,467,000 barrels, in which the oil produced in the southwest Pennsylvania district is stored. The total tankage at Meadowlands at one time was about 2,409,000 barrels, contained in 76 tanks.

A number of wells in the Washington field have produced gas in considerable quantities.

FONNER OIL FIELD.

The Fonner is a small field which now produces about 50 barrels of oil per day, from the Gantz and Fifty-foot sands. Some gas is also produced in this field. The operations are carried on by the South Penn Oil Company.

ZOLLARSVILLE GAS FIELD.

This is the great gas field of the quadrangle and has had a large production for the past few years. The yield is principally from the Elizabeth and Bayard sands, though small quantities are found at all the important sand horizons. This field is being operated by the Monongahela Natural Gas Company, the Philadelphia Company, the Carnegie Natural Gas Company, the Greensboro Natural Gas Company, and the Manufacturers Light and Heat Company.

On the extreme western edge of the field several small oil wells were tapped in 1904. One of these, on the Margaret Hill farm (278), flowed 65 to 75 barrels per day.

MISCELLANEOUS WELLS.

A number of miscellaneous wells in various parts of the quadrangle have encountered oil in small quantities. None of them are worth mentioning. Gas wells are more widely distributed, and some of the scattered wells are good producers. One of the more continuous belts of wells runs from the Fonner field northeastward along the Amity anticline to beyond the National pike. Another group occurs in central Somerset Township. The gas in these scattering wells occurs at no particular horizon, but has been found in all sands from the Big Injun down to the Stray below the Elizabeth. The most commonly productive sands are, however, the Gantz, Fifty-foot, Fourth, and Fifth. The majority of the scattering wells were drilled by the Carnegie Natural Gas Company, the Philadelphia Company, and the Manufacturers Light and Heat Company.

PRESSURE OF NATURAL GAS.

The original pressure of gas in the Washington County district was about 500 pounds to the square inch, minute pressure. Since its discovery every gas field in the State has exhibited a constantly diminishing pressure. The pressure is different for the different sands and also varies for a given sand in various parts of the field. Few pressure records are available for publication.

THEORY OF OIL AND GAS.

Early in the history of oil and gas development attempts were made to discover some means of predicting their occurrence. Since 1859 various geologists and others have published papers attempting to solve this problem. Among others T. Sterry Hunt (1859 and 1863), E. B. Andrews (1861), and H. Hoefer (1876) long ago recognized certain general relations of oil and gas pools to the anticlinal structure of the region. It remained for I. C. White and Edward Orton to bring the occurrence before the public in such a way as to force a measure of belief in the theory which they advanced.

THE "ANTICLINAL THEORY."

In an article on the geology of natural gas, published in 1885,[a] White first formulated the "anticlinal theory," in which he showed that nearly all the great gas wells and pools are situated near the crests of anticlinal folds; while wells bored in the synclines on one side or the other of the anticlines more often obtained little or no gas but in many cases large quantities of salt water. In 1892 the same writer published a paper,[b] in which he extended the theory to include the occurrence of oil as well as gas, and stated how he had located the Washington, Mannington, and other large fields by means of the principles involved in the theory.

The view is, in brief, that when the rocks are gently tilted the oil, gas, and salt water contained in them are caused to separate out in the order of their densities; water (if present) in the synclines, oil next above, and gas nearest the crests of the anticlines. In western Pennsylvania and northern West Virginia these accumulations take the form of belts approximately parallel with the axes, in a general northeast-southwest direction. White states various apparent exceptions, but in reality modifications, of the theory, due to the nonparallelism of surface beds with the oil and gas rocks, etc.

Considerable has been written, pro and con, about this theory by various geologists and others, and some have seriously doubted whether it is true. By most geologists the theory is now accepted, not, however, as absolute in its limitation of the occurrence of oil

[a] Science, June 26, 1885. White gives credit to W. A. Earseman, an operator of Pittsburg, who had previously noted the relations of oil and gas to geologic structure.

[b] The Mannington oil field and the history of its development: Bull. Geol. Soc. America, vol. 3, 1892, pp. 187–216; reprinted in part in West Virginia Geol. Survey, vol. 1 (a), Oil and gas, 1904, pp. 54–59.

and gas, but as explaining their occurrence to a considerable extent. The distribution of the pools is dependent also on the presence or absence of water in a given region or a given sand; on the continuity and shape of the anticlines, whether they are ascending or plunging in a given direction; on the porosity of the oil rock, its capacity to hold oil, the directions of its variation, etc.

APPLICATION OF ANTICLINAL THEORY IN PENNSYLVANIA.

Thus far the Pennsylvania folios[a] which have been published show a certain degree of correspondence of distribution of these deposits to geologic structure. The gas fields occur generally on the anticlines; the oil fields part way down the slope if water is present, in the bottom of the synclines if water is absent. To take the Pennsylvania and northern West Virginia fields as a group, the evidence at present seems to warrant the following generalizations regarding structural distribution:

(1) When not affected by other conditions, accumulations of oil and gas show a definite relation to the structure of the region.

(2) The greatest elongation of the pools is generally in a direction approximately parallel with the axes of the folds.

(3) Where both oil and gas occur they are distributed according to their densities, the oil in the lower and the gas in the higher portion of a stratum.

(4) When salt water is present oil may occur in that part of the stratum lying directly above the water level.

(5) Oil may occur on the crests of anticlinal folds below water level.

(6) When salt water is absent the occurrence of oil is more irregular and more affected by other conditions; it may occur along the synclinal axes or at many points scattered over the slope.

(7) Oil may occur on a structural slope at points where the dip changes from gentle to steep.

(8) Gas occurs most commonly on the higher portions of the anticlinal arches, above the upper level of the oil.

(9) Gas also occurs in widely scattered localities, owing to small local folds or changes in porosity.

Structure is not the only condition determining the occurrence of gas and oil. The structure may be favorable, yet neither oil nor gas occur. The chief condition other than those given above is the existence of rock of such character as to act as a reservoir.

RELATION OF OIL AND GAS RESERVOIRS IN THE AMITY QUADRANGLE TO GEOLOGIC STRUCTURE.

Washington field.—A study of the geologic map of the Amity quadrangle with reference to the distribution of oil and gas shows

[a] Geologic Atlas U. S., folios 82, 92, 94, 102, 110, 115, 121, 123, 125, 134.

certain relations which hold good with respect to the individual fields. The Washington oil field, the most striking example, is located on the eastern flank of the Washington anticline, which it follows in this quadrangle for a distance of 5 miles. The field averages about a mile in width and in position agrees closely with the lower portion of the steepest grade of the anticlinal slope. The greater proportion of wells are grouped in a belt about a mile wide just above a change in grade from the gentle structural slopes of the bottom of the syncline to the steeper slopes of the anticline. Along this belt the dip of the rocks is unusually steep—about 200 feet in a mile. This is the steepest continuous dip in the quadrangle and is greater than usually occurs in Pennsylvania oil fields. It will be noticed that the map shows a nose-like projection from the axis directly east of the Manifold mine, and that a projection of the oil field agrees with this.

One small area in the Washington field—the group of wells west of Gambles—shows structural relations somewhat different from those in the rest of the field. This area is near the north end of the Washington field, and here the belt bends to the east and oil occurs down to the bottom of the syncline. As operations in this part of the Washington field ceased long ago, it is difficult to obtain data for drawing conclusions regarding the cause of these peculiar conditions. It is suggested, however, that if the rocks directly below this pool are dry the oil may have descended from farther up the slope, and thus the relations of the field may be accounted for. Another peculiar feature of this field is the presence of a number of gas wells in the bottom of the syncline north of Linden. Such an occurrence is exceptional, as gas is more often present on the anticlines. The gas occurs, however, above the oil, as would be expected.

Examples of the anticlinal tendency of gas.—A typical illustration of the structural relations of natural gas is afforded by the scattered wells lying high up on the Washington anticline in Chartiers and western North Strabane and South Strabane townships, where they occur over a broad arch in the strata. The Canonsburg gas field is a continuation of this belt.

Perhaps the best illustration of the anticlinal tendency of gas is afforded by the Amity anticline, between the Greene County line and Kammerer. This anticline is a rather broad arch having gentle dips at its crest, and along it occur a large number of gas wells.

Zollarsville field.—The principal gas field of the quadrangle—the Zollarsville field—can not be said to hold any definite structural position. Instead of occurring high up on the anticline southeast of Deemston, as might be expected, it lies on the west flank of the anticline and stretches over nearly the entire synclinal slope between

Beallsville and Zollarsville, a few wells occurring nearly to the center of the basin. The apparent disregard of structure here may perhaps be due to the nonparallelism of the oil sands and the Pittsburg coal, but the data at hand are not sufficient to permit the accurate drawing of contours on any sand. Near the axis of the syncline, southwest of Beallsville, oil has been struck in several wells.

Summary.—The distribution of oil and gas in the quadrangle as a whole can be said to show a fair agreement with the geologic structure. The most favorable location for oil seems to be on the flanks of the anticlines, and for gas either on the broad anticlinal arches or the upper part of the synclinal slopes—always, however, higher up the slope than where oil is found.

ORIGIN OF OIL AND GAS.

The theories for the origin of petroleum and natural gas can be divided into two groups, viz, (1) those which refer these products to inorganic action or chemical affinity in mineral matter, and (2) those which regard them as due to partial decomposition of vegetable and animal matter stored in the rocks. The various modifications of these theories have been discussed in considerable detail by Edward Orton.[a] The theory now most generally accepted by geologists is briefly as follows:

When the Paleozoic rocks were deposited they contained large amounts of carbonaceous matter, the remains of animal and vegetable organisms. This material was present in sufficient quantities to give rise to oil and gas, through the process of decomposition and the physical and chemical changes to which it has been subjected during geologic time. The products may originally have been formed in greater abundance in shales, but when once formed they probably migrated into the more porous rocks, especially sandstones, in which they are now held. As there are at present no surface indications of the presence of either oil or gas, it is probable that considerable quantities have escaped from outcropping strata during the process of erosion.

MISCELLANEOUS NOTES ON OIL AND GAS.

CHARACTER OF THE OIL.

Washington County lies in what is known technically as the southwest district of Pennsylvania and northern West Virginia. All the oil produced in this district is a high grade of petroleum. It has a paraffin base and a high degree of purity. In color it varies somewhat. Though generally green, it is sometimes black, and in a few cases amber or even nearly transparent.

[a] Report Geol. Survey Ohio, vol. 6, Economic geology, 1888, pp. 60–83.

COMPOSITION OF NATURAL GAS.

Chemically, natural gas from the Pennsylvania fields consists chiefly of the hydrocarbons of the paraffin series, with nitrogen, traces of carbon dioxide, oxygen, hydrogen, and ammonia. The chief constituent is methane (CH_4), the lowest member of the paraffin series of hydrocarbons. Methane is one of the products of the destructive distillation of coal and consequently constitutes a large proportion of ordinary coal gas. It is also produced in association with hydrogen when plants decay at the bottom of rivers and swamps. The name "marsh gas" is therefore sometimes applied to it. Methane, when pure, is odorless and not poisonous. Its specific gravity is 0.55297. One cubic meter weighs 0.7148 kilogram; 1 cubic foot, 312.36 grams. Methane requires twice its volume of oxygen, or 10 volumes of air, for its complete combustion, and the products are carbon dioxide and water vapor.

Occasionally a well yields this gas in a nearly pure condition. Generally, however, there is quite a proportion of impurities. A number of analyses have been made at various times of gas from Pennsylvania wells. One of these is from the Houston well at Houston, one-third of a mile west of the station, on Plum Run. The well is 1,794 feet deep and is drilled nearly through the Gantz sand. The Salt sand and its gas were found at 850 feet, but this was cased off. The well may therefore be considered as yielding gas from the Gantz sand exclusively. The gas from the Salt sand is said to burn with a whiter but more sooty flame than that from the greater depth. The occurrence of an upper, less productive sand, yielding gas of greater illuminating power, is said to be a common feature in the gas fields of the State. The sample of gas was collected on March 18, 1887. The analysis is given below:[a]

Analysis of gas from the Houston well.

Nitrogen	15.30	Oxygen	Trace.
Carbon dioxide (CO_2)	44	Hydrogen sulphide (H_2S)	0
Hydrogen	0	Parraffins (mostly) (CH_4)	84.26
Ammonia (NH_3)	Trace.		
			100

The paraffins mentioned in this analysis have the following average composition: Carbon, 76.68 per cent; hydrogen, 23.32 per cent.

The following analysis represents a fair average for Pennsylvania natural gas in general and is given here for comparison:

Average analysis of natural gas in Pennsylvania and West Virginia.[b]

Marsh gas (CH_4)	80.85	Hydrogen	0.10
Other hydrocarbons	14	Hydrogen sulphide (H_2S)	0
Nitrogen	4.60	Oxygen	Trace.
Carbon dioxide (CO_2)	.05		
Carbon monoxide (CO)	40		100

[a] White, I. C., West Virginia Geol. Survey, vol. 1 (a), Oil and gas, 1904, p. 539.

[b] Oliphant, F. H., The production of natural gas; extract from Mineral Resources U. S. for 1904, U. S. Geol. Survey, 1905, p. 12.

WASTE OF NATURAL GAS.

The waste of natural gas in the western Pennsylvania and Ohio fields in the early days of production was enormous. From some wells it has been estimated as equivalent to hundreds of tons of coal per day. This was due largely to the enormous pressure developed at the outset in some of the big producers. Measures were soon taken to stop the waste. The gas from the McGuigan well, however, as already stated, flowed away for more than a year before a main was laid to Pittsburg.

Aside from the waste due to uncontrollable pressure in the early wells, there has been a great deal of loss of gas owing to the fact that the producers and consumers were careless in its transportation and utilization. Much gas is still wasted through unplugged wells, from leaky joints, and from producing oil wells. Many farmers who own gas wells foolishly allow the gas to burn all day from pipes in front of their houses. In one case gas was observed burning at the top of a pipe in the center of a corn field. The writer has passed through villages where the street lights were allowed to burn all day. I. C. White has estimated that in West Virginia one-fourth of the entire production is daily wasted without accomplishing any useful purpose.[a] Recently there has been a gradual awakening to the inexcusable waste, and it is hoped that before long all the gas produced will be utilized.

VALUE OF GOOD WELL RECORDS.

The advantage of keeping accurate and complete records of the wells is almost universally underestimated. In the great majority of cases only one or two coal beds and the principal oil and gas sands are noted by the drillers. These answer their purpose for recognizing the sands, but tell nothing of the character or distribution of the intervening formations, and thereby render it impossible to draw any geologic conclusions of value.

A few drillers and contractors have kept records in which the thickness and depth of all beds from the surface to the bottom of the well have been noted. It is urged that more such records be kept. Especially is it important to note the positions and character of all coal, red shale, and limestone beds, as on these the geologist depends most of all for his correlations. Such data assist in the determination of geologic structure and frequently enable him to define the limits of a certain formation, and thus to give the geologic name corresponding to the driller's term for a certain sand. To meet the needs of drillers and other persons who wish to keep pace with the most modern methods of taking notes, the United States Geological Survey keeps in stock a large number of pocket record books, which may be

[a] West Virginia Geol. Survey, vol. 1 (a), Oil and gas, 1904, p. 30.

obtained without cost by all drillers who desire them. The covers of these notebooks contain a few geologic notes and suggestions to drillers. The Survey is also glad to receive samples of formations passed through at various depths in the wells, as by careful study and comparison it is frequently possible for the geologists to make interpretations which the record alone will not give.

RECORDS OF WELLS IN THE AMITY QUADRANGLE.

For the convenience of persons prospecting and operating in this region the following table has been prepared, giving the depths to the principal oil and gas sands and other important beds penetrated by the drill. The accuracy of these figures can not be vouched for, but they are taken from the best available records furnished by the drillers.

Depths, in feet, to coals and principal

[From records furnished by the owners. *Signifies that the figures given represent the depths of gas by level. All other elevations

No. on Pl. I.	Elevation.	Name of well.	Owner.	Product.	Producing sand.
		Amwell Township.			
1	1,135	Daniel Baker, No. 1		Dry?	
2	1,215	Zach Baker		Gas	Fifty-foot
3	1,010	Baker		do	
4	1,050?	Bebout			
5	940	Clark Hackney, No. 1	Fergus Oil Co	Dry	
6	950	Hackney, No. 2	Carnegie Natural Gas Co.?		
7	1,320	Jas. M. Kuntz, No. 1?	do		
8	960	Meloy, No. 1	Tenmile Oil Co	Gas	
9	968	Meloy, No. 2	do	do	
10	.....	Grant Moniger, No. 2 (or 3).	Carnegie Natural Gas Co.	do	
11	1,110	Onias Moniger		do	
12	950	Swart		Dry	
13	1,020	Webb, No. 1	Carnegie Natural Gas Co.	Gas	
		Borough of Beallsville.			
14	1,160	Mrs. A. L. Hawkins, No. 2.	Manufacturers' Light and Heat Co.	Gas	
15	1,070	Luse, No. 1	Greensboro Natural Gas Co.	do	Bayard
16	1,095	A. C. Mitchell, No. 1	do	do	
		Borough of Bentleyville.			
17	1,030	Mrs. R. L. Jones	Philadelphia Co	Gas	
18	955	J. G. McCormick, No. 1.	do	Dry	
		Chartiers Township.			
19	955	Arnold, No. 1	Philadelphia Co		
20	1,120	Peter Martin, No. 1	do	Gas	
21	1,000	C. R. Riggle, No. 2	Manufacturers' Light and Heat Co	do	
		Borough of Deemston.			
22	1,185	Burkehammer, No. 1	Monongahela Natural Gas Co.	Gas	
23	1,035	N. T. Clark, No. 1	Manufacturers' Light and Heat Co.	do	
24	865	A. B. Crumrine, No. 1	Greensboro Natural Gas Co.	do	Elizabeth
25	1,115	Demas Crumrine, No. 1	Manufacturers' Light and Heat Co.	do	
26	1,105	Volluntyne Crumrine, No. 1.	Monongahela Natural Gas Co.		
27	1,035	Volluntyne Crumrine, No. 2.	do	Gas	
28	925	Wm. Crumrine No. 1	Greensboro Natural Gas Co.	do	Elizabeth
29	840	Matilda Davis, No. 2	do	do	
30	965	F. L. Hastings, No. 1	Monongahela Natural Gas Co.		
31	1,045	Mrs. A. L. Hawkins, No. 1.	Manufacturers' Light and Heat Co.	Gas	

sands in the Amity quadrangle.

or oil in the sand; † signifies known steel line measurement; L means that the elevation was determined were determined by aneroid barometer.]

Depth to—															
Waynesburg coal.	Mapletown coal.	Pittsburg coal.	Upper Freeport coal.	Salt sand.	Big lime.	Big Injun sand.	Thirty-foot sand.	Gantz sand.	Fifty foot sand.	Gordon Stray sand.	Gordon sand.	Fourth sand.	Fifth sand.	Bayard sand.	Elizabeth sand.
205	.....	525	.....	1,441	1,664	1,705	2,277	2,431	2,465	2,567	2,705	2,784	2,817	.....	3,031
.....	.....	640	.....	.....	.....	.....	.....	.....	2,549	.....	.....	.....	.....	.....	.....
225	.....	562	.....	.....	1,678	1,710	2,575	2,425	2,475	2,660	2,685	2,770	2,835	.....	.....
.....	.....	602	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
140	.....	453	.....	1,425	.....	1,645	.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	.....	485	.....	.....	.....	.....	2,390	.....	.....	.....	.....	.....	.....	.....	.....
.....	.....	.....	.....	.....	.....	1,910	.....	.....	.....	.....	.....	.....	.....	.....	.....
144	.....	455	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
144	.....	455	.....	.....	.....	1,610	.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	.....	532	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	.....	528	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	.....	460	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	.....	.....	.....	.....	.....	1,648	.....	.....	2,355	.....	2,600	2,680	.....	.....	.....
67	.....	400	.....	1,360	1,595	1,645	2,140	2,333	2,373	.....	.....	2,622	2,672	2,819	2,894
112	318	434	.....	.....	.....	1,650	.....	2,350	2,401	.....	.....	.....	2,770	2,920	.....
.....	.....	.....	936	.....	1,483	1,545	.....	.....	2,270	2,450	2,495	.....	.....	2,670?	2,800?
.....	.....	308	.....	1,240	.....	1,528	.....	.....	.....	.....	.....	.....	2,610	.....	2,788
.....	.....	180	.....	1,089	.....	.....	.....	.....	.....	.....	2,344	.....	.....	.....	.....
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1,992	.....	.....	.....	.....
.....	.....	160	.....	.....	.....	1,252	.....	.....	2,010	2,144	2,190	.....	.....	.....	.....
.....	.....	.....	.....	.....	.....	.....	.....	1,753	.....	.....	.....	.....	.....	.....	.....
.....	.....	458	.....	1,380	.....	1,750	2,320	2,380	2,515	.....	2,664	2,750	2,805	2,856	2,950
90	315	420	1,100	1,357	.....	1,650	2,274	2,350	2,420	.....	2,600	2,670	.....	2,786	2,925
.....	85	208	812	1,129	.....	1,454	.....	.....	.....	.....	.....	.....	.....	2,592	2,698
.....	.....	478	.....	.....	1,630	1,695	.....	2,380	2,469	.....	2,693	.....	2,803	2,872	2,971
.....	.....	387	990	1,345	.....	1,638	2,110	2,330	2,370	.....	.....	.....	2,755	2,795	2,890
.....	.....	397	1,000	1,355	.....	1,648	2,120	2,340	2,380	.....	.....	.....	2,765	2,805	2,900
.....	.....	265	845	1,200	1,450	1,520	2,130	2,190	2,245	.....	.....	.....	.....	2,675	2,760
.....	.....	200	804	.....	1,405	1,455	.....	2,120	.....	2,387	2,402	.....	.....	.....	.....
.....	.....	200	.....	1,100	.....	1,450	.....	2,170	.....	.....	2,430	.....	2,553	2,620	2,705
.....	298	425	.....	1,413	1,589	1,645	.....	.....	2,342	.....	.....	.....	.....	.....	.....

Depths, in feet, to coals and principal

[From records furnished by the owners. *Signifies that the figures given represent the depths of gas by level. All other elevations

No. on Pl. I.	Elevation.	Name of well.	Owner.	Product.	Producing sand.
		Borough of Deemston—Continued.			
32	1,035	Mrs. A. L. Hawkins, No. 3.	Manufacturers' Light and Heat Co.	Gas	
33	1,000	L. V. Martindale, No. 1	do		
34	1,080	L. V. Martindale, No. 2			
35	1,225	Wm. Michiner, No. 1	Monongahela Natural Gas Co.	Gas	
36	915	Jas. M. Miller, No. 1	do		
37	1,050	W. S. Morey, No. 1	do		
38	845	Oberholt, No. 1	do	Gas	
39	875	Porter, No. 1	Carnegie Natural Gas Co.	do	
40	995	Geo. T. Regester, No. 1.	Monongahela Natural Gas Co.	do	
41	1,165	Spindler, No. 1	do	do	
42	1,155	David Teagarden, No. 1.	do	do	
43	1,045	Hiram Teagarden, No. 1.	do	do	
44	1,175	J. L. Thompson, No. 1	Greensboro Natural Gas Co.	do	
45	1,105	J. L. Thompson, No. 2	do	do	
46	1,045	J. L. Thompson, No. 3	do	do	Elizabeth
47	1,020	J. L. Thompson, No. 4	do	do	Bayard
48	1,030	J. L. Thompson, No. 5	do	do	Elizabeth
49	1,045	Wm. Ward	Monongahela Natural Gas Co.		
50	1,235	A. M. Wickerham, No. 1.	do		
51	925	John B. Wise, No. 2	Philadelphia Co	Gas	
52	1,005	Mary S. Wise, No. 1?	do	do	Elizabeth
53	1,090	Grant Zollars, No. 1	Monongahela Natural Gas Co.	do	
		East Bethlehem Township.			
54	1,200	Blakely, No. 1	Monongahela Natural Gas Co.	Gas	
55	1,145	Selig heirs	do		
		Morris Township, Greene County.			
56	1,270	Bristor Bros., No. 3	South Penn Oil Co	Oil	Gantz
57	1,265?	Crummerine		Gas	do
58	1,485	Wm. Fonner, No. 4	South Penn Oil Co	Oil	do
59	1,170	Abner Lacock	J. L. Dunn & Co	do	Hundred-foot
60	1,228	Elmas Loughman, No. 1.	Tim Ross & Co	do	Gantz
61	1,170	John Ross, No. 1?		Gas	do
		Morris Township, Washington County.			
		Carey, No. 1	Tim Ross & Co	Oil	Fifty-foot
62	1,130	Elmas Carey, No. 1	Dunns Station Oil Co	do	do
63	1,050	D. A. Conger	J. L. Dunn & Co		
64	990	Ringland	Carnegie Natural Gas Co	Gas	Gantz
65	1,350	J. L. Dunn, No. 1	Dunns Station Oil Co	Oil	do
66	1,090	Dunn, No. 2	do		

ands in the Amity quadrangle—Continued.

r oil in the sand; † signifies known steel line measurement; L means that the elevation was determined
ere determined by aneroid barometer.]

				Depth to—											
Waynesburg coal.	Maple town coal.	Pittsburg coal.	Upper Freeport coal.	Salt sand.	Big lime.	Big Injun sand.	Thirty-foot sand.	Gantz sand.	Fifty-foot sand.	Gordon Stray sand.	Gordon sand.	Fourth sand.	Fifth sand.	Bayard sand.	Elizabeth sand.
67	.....	400	.....	1,369	1,595	1,645	2,140	2,333	2,373	.....	.....	2,622	2,672	2,819	2,894
.....	.....	400	.....	1,334	1,560	1,640	.....	2,315	2,400	.....	2,550	.....	2,726	2,772	2,884
155	.....	485	.....	1,425	1,655	1,710	.....	2,400	2,430	2,580	2,675	2,705	2,785	2,890	2,985
.....	.....	485	.....	1,420	.....	1,720	.....	.....	2,455	.....	2,680	.....	.....	2,890	2,985
.....	.....	380	.....	1,280	.....	1,580	2,200	2,330	.....	.....	.....	.....	.....	.....	.....
.....	.....	408	.....	1,320	.....	1,650	2,210	2,340	2,381	.....	2,620	.....	2,735	2,817	2,909
.....	.....	210	810	1,150	.....	1,450	.....	2,100	2,207	.....	2,357	2,447	.....	2,547	2,697
.....	.....	240	.....	.....	.....	1,198	.....	2,134	2,201	.....	2,423	2,457	2,457	2,461	2,729
.....	.....	395	.....	1,360	.....	1,630	.....	2,325	2,422	.....	2,610	.....	.....	2,765	2,892
.....	.....	480	.....	1,280	.....	1,728	2,290	2,390	2,420	.....	2,660	.....	.....	2,910	3,010
.....	.....	426	.....	.....	.....	1,660	.....	.....	2,400	.....	.....	.....	2,785	2,835	2,725
.....	.....	412	1,020	1,330	.....	1,650	2,225	2,335	2,390	.....	.....	.....	.....	.....	2,908
190	.....	530	.....	.....	.....	1,775	.....	.....	.....	.....	.....	.....	.....	.....	.....
150	410	506	1,075	.....	1,659	1,692	.....	.....	2,460	.....	.....	2,724	2,780	2,874	2,995
40	.....	375	980	1,335	1,580	1,440	2,220	2,340	2,380	.....	.....	.....	.....	2,797	2,881
21	.....	358	960	1,315	1,564	1,628	2,200	2,320	2,360	.....	.....	.....	.....	2,786	.....
58	221	388	940	1,250	1,572	1,617	.....	2,307	2,362	2,520	2,550	2,585	2,675	2,770	2,882
.....	.....	225	810	1,118	.....	1,460	2,035	2,150	2,195	.....	.....	.....	.....	2,634	2,712
.....	.....	519	1,240	1,440	.....	1,756	2,375	2,445	2,490	.....	.....	.....	.....	2,915	3,019
.....	.....	305	.....	.....	.....	1,538	.....	2,260	.....	.....	2,428	.....	.....	2,709	2,788
.....	.....	380	.....	.....	.....	1,600	.....	2,310	.....	.....	.....	2,596	.....	2,782	2,853
.....	.....	430	1,030	1,360	.....	1,675	2,250	2,340	2,396	.....	.....	.....	.....	.....	2,919
20	.....	375	.....	.....	1,550	1,615	.....	.....	2,335	.....	.....	.....	.....	2,765	2,865
.....	.....	315	.....	1,215	.....	1,565	.....	2,285	.....	.....	.....	.....	.....	.....	2,812
515	712	860	.....	1,810	1,990	1,935	.....	2,771	.....	.....	.....	.....	.....	.....	.....
.....	.....	835	.....	.....	.....	.....	.....	2,742	.....	.....	.....	.....	.....	.....	.....
.....	.....	1,030	.....	.....	2,160	2,230	2,780	2,954	.....	.....	.....	.....	.....	.....	.....
.....	.....	1,035	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	.....	835	.....	.....	.....	2,025	.....	2,764	.....	.....	.....	.....	.....	.....	.....
.....	.....	735	.....	.....	.....	.....	.....	2,645	.....	.....	.....	.....	.....	.....	.....
.....	.....	880	.....	.....	.....	2,100	.....	2,774	2,812	.....	.....	.....	.....	.....	.....
.....	.....	725	.....	1,490	1,840	1,890	2,485	2,630	2,672	.....	.....	.....	.....	.....	.....
.....	.....	640	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	.....	506	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	.....	919	.....	.....	.....	.....	.....	2,830	.....	.....	.....	.....	.....	.....	.....
.....	.....	686	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

Depths, in feet, to coals and principal

[From records furnished by the owners. *Signifies that the figures given represent the depths of gas by level. All other elevations

No. on Pl. I.	Elevation.	Name of well.	Owner.	Product.	Producing sand.
		North Franklin Township.			
67	1,305	Isaac Elmer, No. 1	Manufacturers' Light and Heat Co.		
68	1,135	Wm. Knox, No. 1	do		
69	1,220	W. H. McElree, No. 1	do	Dry	
70	1,165	M. Mounts	do		
71	1,250	Mrs. Snyder	do	Oil and gas	
		North Strabane Township.			
72	995	Jacob Bell	Linden Oil Co	Dry	
73	920	Bell, No. 2	Jefferson Gas Co	Gas	Fifth
74	985	Bell, No. 3	do	do	do
75	1,025	Matthew Berry, No. 1		do	
76	1,000	Matthew Berry, No. 3	Manufacturers' Light and Heat Co.	do	
77	1,110?	Fife heirs, No. 1 (?)	Jefferson Gas Co	do	
78		Fife heirs, No. 2	do	Dry	
79	1,245	Robt. Herron heirs, No. 1.	Manufacturers' Light and Heat Co.	Oil	Gantz
80	1,115	Robt. Herron heirs, No. 2.	do	do	do
81	1,100	Robt. Herron heirs, No. 3.	do	do	
82	985	E. T. Hitchman, No. 1	Canonsburg Light and Heat Co.	Dry	
		Hixon	Jefferson Gas Co		
83	935	A. C. Horner	do	Dry	
84	1,075	Robt. Johnson, No. 1	Manufacturers' Light and Heat Co.	Gas	
85	1,295	Bella Lyle (?)	Jefferson Gas Co	do	Fifth
86	1,120	Sam Linn, No. 3	Manufacturers' Light and Heat Co.	Oil	
87	1,080	Sam Linn, No. 4	do	do	
88	1,120	Sam Linn, No. 5	do	Oil	
89	1,230	Sam Linn, No. 6	do	Gas	
90	1,140	J. B. McBride, No. 2	do		
91	995	J. J. Manes, No. 1	Philadelphia Co	Gas	
92	955?	John P. Manes, No. 1	do	do	
93	1,010?	John P. Manes, No. 2	do	do	Fifth
94	1,025	Jas. V. Manes, No. 1	do	do	do
		Martin, No. 9	Jefferson Gas Co	Oil	Gantz
		Martin, No. 11	do		
95		A. E. Mollenauer	do		
96	1,180	H. P. Mollenauer, No. 1.	Manufacturers Light and Heat Co.	Oil	
		do	do		
97	1,140	H. P. Mollenauer, No. 2.	do	Oil	
98	1,155	H. P. Mollenauer, No. 3.	do	do	
99	983L	H. P. Mollenauer, No. 4.	do	Gas	
100	1,070	H. P. Mollenauer, No. 5.	do	do	
101	995L	J. W. Pollock, No. 1	do	Oil	

sands in the Amity quadrangle—Continued.

or oil in the sand; † signifies known steel line measurement; L means that the elevation was determined were determined by aneroid barometer.]

Depth to—															
Waynesburg coal.	Mapletown coal.	Pittsburg coal.	Upper Freeport coal.	Salt sand.	Big lime.	Big Injun sand.	Thirty-foot sand.	Gantz sand.	Fifty-foot sand.	Gordon Stray sand.	Gordon sand.	Fourth sand.	Fifth sand.	Bayard sand.	Elizabeth sand.
		735				1,960		2,555	2,625			2,895	2,942½		
		568								2,550			2,775		
		635		1,540		1,755	2,250	2,455	2,515	2,677	2,715	2,764			
		590		1,490		1,740		2,420	2,472	2,642	2,680	2,755	2,796		
		654									2,724				
		250													
		175											*†2,397		
		245											*†2,472		
		110													
		24													
		295							*†2,200						
		240													
		550						2,375							
		415						2,253							
		385						2,228	2,278						
											2,065				
		350											†2,555		
		170													
		170													
		490	1,300	*†1,412					2,415				2,730		
		390						2,216	2,270						
		350						2,197					2,558		
		398						2,261	2,270						
		515						2,348	2,726						
		245													
		211				1,360	1,865	2,050		2,312	2,340	2,371	2,425		
		222				1,338	1,895	2,023	2,085	2,263	2,313	2,401	2,450		
		293		1,180				2,110			2,370		2,479		
		270		1,210		1,405			†2,215	2,350	2,385		2,470		
		340						-2,215							
		350											†2,540		
		285													
		464						2,308½	2,363						
		410										2,530			
		455						2,291	2,358						
		435						2,283	2,333						
		240				1,390		2,084	2,124	2,307	2,335	2,378	2,450		
		310		1,210		1,447		2,157	2,200	2,374	2,396	2,448	2,523		
		280						2,100	2,162				2,490		

Depths, in feet, to coals and principal

[From records furnished by the owners. *Signifies that the figures given represent the depths of gas by level. All other elevations

No. on Pl. I.	Elevation.	Name of well.	Owner.	Product.	Producing sand.
		North Strabane Township—Continued.			
102	1,205	J. W. Pollock, No. 2	Manufacturers' Light and Heat Co.	Oil	
103	1,075	J. W. Pollock, No. 3	do	do	
104	1,145	J. W. Pollock, No. 5	do	do	
105	1,050±	J. W. Pollock, No. 6	do	do	
106	1,305	Quail, No. 1	McKeown Oil Co	do	Fifty-foot
107	1,305	Quail, No. 2	do		
108	960?	Mrs. C. M. Reed	Associated Producers Co		
109	1,325	"Rooney well" (No. 2)	Chartiers Oil Co	Oil	
110	1,300	Rooney, No. 5	Manufacturers Light and Heat Co.	Gas	
111	1,015	Thos. Templeton, No. 1	Philadelphia Co	do	
112		Thome, No. 1	Jefferson Gas Co		
113		Thome, No. 3	do		
114		Thome, No. 4	do		
		Thome, No. 5	do	Gas	Fifth
115	920	Washerbaugh, No. 1	do		
116		Washerbaugh, No. 2	do	Gas	
117		Washerbaugh, No. 3	do	do	
118	1,155	Joshua Wright, No. 1	Chartiers Oil Co	do	Gantz
119		Joshua Wright, No. 4	do	Oil	do
		Nottingham Township.			
		Hoffer, No. 1	Carnegie Natural Gas Co	Dry	
120		E. T. Hyde	Liberty Oil and Gas Co	do	
121		McClean heirs		do	
122	1,180?	James Thomas (?)	Philadelphia Co		
		Somerset Township.			
123	1,175?	Henry Andrews, No. 1 (?)	Carnegie Natural Gas Co	Dry	
124	1,275	J. W. Frost, No. 1	do		
125	1,100	J. W. Frost, No. 2	do		
126	1,115	Andrew Gamble	Philadelphia Co	Dry	
127	1,170	Eli Hawkins, No. 1	Monongahela Natural Gas Co.	Gas	
128	1,006	A. Hetherington, No. 1	Philadelphia Co	Dry	
129	975	J. A. Hoffman	Monongahela Natural Gas Co. (?)		
130	985	J. J. Hoffman	Fergus Oil Co	Gas	
131	1,135	Mrs. M. A. Jones	Loury Oil Co		
132	1,200	Joseph Kammerer		Gas	
133	1,280	Margaret Martin, No. 1	Monongahela Natural Gas Co.		
134	1,265	J. M. Oller, No. 1	Philadelphia Co	Dry	
135	1,090	A. T. Scott, No. 1	Monongahela Natural Gas Co.		
136	1,100	Isaac Tombaugh, No. 2 (?)	Philadelphia Co	Dry	
		South Franklin Township.			
137	1,145	Doctor Dodd			
138	1,150	Ira Lacock	Forest Oil Co	Oil (little)	
139	1,170	Jas. McClintock			

sands in the Amity quadrangle—Continued.

or oil in the sand; † signifies known steel line measurement; L means that the elevation was determined were determined by aneroid barometer.]

Depth to—															
Waynesburg coal.	Mapletown coal.	Pittsburg coal.	Upper Freeport coal.	Salt sand.	Big lime.	Big Injun sand.	Thirty-foot sand.	Gantz sand.	Fifty-foot sand.	Gordon Stray sand.	Gordon sand.	Fourth sand.	Fifth sand.	Bayard sand.	Elizabeth sand.
		490						2,343	2,376						
		359						2,192							
		436						2,271½	2,322						
		324						2,165	2,211½						
								2,360	2,414						
								2,355	2,409						
		260	860						2,147						
								2,367	2,414				2,740		
		599			1,706	1,745		2,432	2,489						
		262		1,117			1,937	2,104	2,140			2,42[illegible]	2,475		
													2,630		
		480											†2,700		
		590											2,795		
		420											†2,625		
		190											†2,380		
		350											†2,565		
		440											*†2,655		
								2,211½	2,255						
								2,329	2,348						
		65				1,310	1,880		2,040				2,400		
		365			1,500	1,450									
		(a)											2,480		
	230	332		1,200		1,520		2,247	2,279					2,722	
		632				1,763				2,370	2,765	2,810	2,875		
		510													
		360													
		320				1,476		2,227	2,260		2,480			2,710	
		355		1,250		1,560	2,160	2,295							
		258		1,195		1,475							2,558		2,740
		225							2,200						
		295				1,400									
		508						2,315½							
		395				1,650	2,180	2,380			2,598	2,719	2,795		
		500					2,295								
		431													
		315	945	1,225		1,650	2,106								
		410				1,606		2,320							
		714						2,594							
		700							2,602	2,792		2,871	2,908		
		648											2,800		

a Coal reported missing.

Depths, in feet, to coals and principal

[From records furnished by the owners. *Signifies that the figures given represent the depths of gas by level. All other elevations

No. on Pl. I.	Elevation.	Name of well.	Owner.	Product.	Producing sand.
		South Strabane Township.			
140	1,079L	Wm. Barre, No. 1	Forest Oil Co	Oil	
141	1,115	Wm. Barre, No. 3	do		
142	1,260	Wm. Barre, No. 4	do		
143	1,315	Wm. Barre, No. 5	do		
144	1,265	Wm. Barre, No. 6	do		
145	1,320	Wm. Barre, No. 7	do		
146	1,340	Wm. Barre, No. 8	do	Oil	Gantz
147	1,275	Wm. Barre, No. 9	do	do	do
148	1,265	Wm. Barre, No. 10	do	do	Gantz, Fifty-foot.
149		Wm. Barre, No. 11	do	do	Gantz, Gordon
150	1,325	Wm. Barre, No. 12	do	do	Gantz, Fifty-foot.
151	1,190	Wm. Barre, No. 13	do	do	do
152	1,142L	J. & G. M. Cameron, No. 2.	Chartiers Oil Co	do	Gantz
153	1,210	J. & G. M. Cameron, No. 3.	do	do	do
154	1,333	J. & G. M. Cameron, No. 5.	do	do	
155	1,192	J. & G. M. Cameron, No. 6.	do	do	Gantz, Fifty-foot.
156	1,285	J. & G. M. Cameron, No. 9.	do	do	Gantz
157	1,255	J. & G. M. Cameron, No. 11.	do	do	do
158	1,260	J. & G. M. Cameron, No. 12.	do	Oil and gas	Gantz, Fifty-foot.
159	1,260?	J. & G. M. Cameron, No. 13.	do	Oil	Gantz
160	1,325	William Davis, No. 1	Associated Producers Co	do	Gantz, Fifty-foot.
161	1,280	William Davis, No. 2	do	do	do
162	1,260	William Davis, No. 3	do	do	do
163	1,215	William Davis, No. 4	do	do	do
164		William Davis, No. 5	do	do	Gantz
165	1,200	William Davis, No. 7	do	do	do
166	1,235	William Davis, No. 8	do	do	Fifty-foot, Gantz.
167	1,325	William Davis, No. 9	do	do	Fifty-foot
168	1,255	William Davis, No. 10	do	do	Gantz
169	1,200	Fergus, No. 1		do	do
170	1,110?	do	Fergus Oil Co	do	
171	1,115	Fergus, No. 2 (?)	Hanover Oil Co		
172	1,115	Fergus, No. 4 (?)		Oil	Gantz
		S. P. Fergus, No. 1	Chartiers Oil Co	do	do
		S. P. Fergus, No. 2	do	do	Gantz, Fifty-foot.
	1,286L	S. P. Fergus, No. 5	do	do	Gantz
		S. P Fergus, No. 6	do		do
		S. P. Fergus, No. 7	do	Oil	do
		S. P. Fergus, No. 11	do	do	do
173	1,140	Robert Forest, No. 1	Forest Oil Co	Oil	
174		Kountz, No. 1	People's Gas Co	Dry	
175	1,165	Kountz, No. 2	do		
176	1,065	Kountz, No. 3	W. F. Borchers	Dry	
177	1,220	J. H. Little, No. 1	Carnegie Natural Gas Co		

nds in the Amity quadrangle—Continued.

oil in the sand; † signifies known steel line measurement; L means that the elevation was determined ere determined by aneroid barometer.]

Depth to—																
Waynesburg coal.	Mapletown coal.	Pittsburg coal.	Upper Freeport coal.	Salt sand.	Big lime.	Big Injun sand.	Thirty-foot sand.	Gantz sand.	Fifty-foot sand.	Gordon Stray sand.	Gordon sand.	Fourth sand.	Fifth sand.	Bayard sand.	Elizabeth sand.	
								2,209	2,239							
								2,398½	2,318	2,348						
								2,398½								
		612						2,446								
								2,435								
								2,518	2,577							
								2,487								
								2,431								
								2,400	2,470							
								2,280			2,314					
								2,530	2,594							
								2,309	*2,430							
		460				1,590		2,262½								
		620						2,343								
		550						2,433								
								2,386	2,430							
								2,455								
		615						2,379	2,471							
		607						2,432			2,700	2,750	2,808			
								2,419								
		659						2,480								
		630						2,453	2,518							
		625						2,454	2,511							
								2,393	2,456							
		642						2,467	2,521							
								2,389	2,452							
								2,437	2,488							
								2,497	2,552							
								2,421	2,482							
								2,394								
		530		1,492	1,646	1,680		2,460								
		548		1,500		1,700	2,180	2,391		2,583	2,609	2,649	2,723			
								2,365	2,420							
								2,456	2,517							
		595				1,830		2,457½	2,512							
		16		1,560				2,450								
		526						2,350								
		610						2,461								
		590						2,405								
		420						2,250	2,309	2,497	2,528	2,573	2,643			
		420						2,180		2,401						
		470														
		234														
							2,415	2,485	2,595			2,945				

Depths, in feet, to coals and principal

[From records furnished by the owners. *Signifies that the figures given represent the depths of gas by level. All other elevations

No. on Pl. I.	Elevation.	Name of well.	Owner.	Product.	Producing sand.
		South Strabane Township—Continued.			
178	1,075	J. D. McNary, No. 1	Chartiers Oil Co	Oil	Fifty-foot
179	1,215	J. D. McNary, No. 2	Manufacturers' Light and Heat Co.		
180	1,060?	Manifold, No. 1 (?)	Manifold Oil Co		
181	1,045?	Manifold, No. 2 (?)			
182	1,200	Martin Bros., No. 1	McKeoun Oil Co	Oil	Gantz
183	1,120	Martin Bros., No. 2	do	do	do
184	1,160	Martin Bros., No. 3	do		
185	1,115	Martin Bros., No. 4	do		
186	1,255	Martin Bros., No. 5	do	Oil	Gantz
187	1,255	Martin Bros., No. 6	do	do	Gantz, Fifty-foot.
188	1,250	Martin heirs, No. 1	do	do	Fifty-foot
189	1,290	Martin heirs, No. 2	do	do	Gantz
190	1,215	Martin heirs, No. 3	do	do	do
191	1,200	Martin heirs, No. 4	do	do	do
192	1,270	Martin heirs, No. 5	do	do	Gantz, Fifty-foot.
193	1,255	Martin heirs, No. 6	do		
		Morgan, No. 1	Forest Oil Co	Oil	Gantz, Fifty-foot.
194	1,290?	Morgan, No. 2 (?)	do	do	Gantz
		Morgan, No. 3	do	do	do
		Morgan, No. 5	do	do	Gantz, Fifty-foot.
		Morgan, No. 6	do	do	Gantz
		Morgan, No. 7	do	do	do
		Morgan, No. 8	do	do	Gantz, Fifty-foot.
		Morgan, No. 9	do	do	do
		Morgan heirs, No. 11	do	do	Fifth
		R. J. Munce, No. 1	Jefferson Gas Co	Gas	do
		R. J. Munce, No. 2	do		
195	1,345	W. J. Munce, No. 1	McKeoun Oil Co	Oil	Gantz, Fifty-foot.
196	1,305	Munce, No. 2	do	do	Fifty-foot
197	1,360	Munce, No. 3	do	do	Gantz (or Fifty-foot).
198	1,280	Munce, No. 4	do	do	do
199	1,330	Munce, No. 5	do	do	do
200	1,350	Munce, No. 6	do	do	do
201	1,390	Munce, No. 7	do	do	do
202	1,280	Munce, No. 8	do		
203	1,260	Munce, No. 10	do	Oil	Fifty-foot
204	1,280	Munce, No. 12	do	do	Gantz, Fifty-foot.
205	1,260	Munce, No. 13	do	do	do
206	1,350	Munce, No. 14	do	do	do
207	1,240	Munce, No. 15	do	do	Fifty-foot
208	1,085	Munce, No. 16	do	do	
209	1,135	Munce, No. 17	do	do	Gantz, Fifty-foot.
210	1,095	Munce, No. 18	do	do	Fifty-foot
211	1,190	Munce, No. 20	do	do	do
212	1,190	Myers, No. 1	Carnegie Natural Gas Co.	Gas	

sands in the Amity quadrangle—Continued.

or oil in the sand; † signifies known steel line measurement; L means that the elevation was determined were determined by aneroid barometer.]

Depth to—															
Waynesburg coal.	Mapletown coal.	Pittsburg coal.	Upper Freeport coal.	Salt sand.	Big lime	Big Injun sand.	Thirty-foot sand.	Gantz sand.	Fifty-foot sand.	Gordon Stray sand.	Gordon sand.	Fourth sand.	Fifth sand.	Bayard sand.	Elizabeth sand.
								2,109	2,160						
		315									2,404		2,515		
		286				1,440					2,377	2,421	2,498		
						1,400									
								2,290							
								2,293							
									2,448						
								2,290							
								2,415	2,469						
		506						2,359	2,412						
								2,348	2,409						
								2,428							
								2,328	2,384						
								2,319							
								2,296	2,350						
								2,360							
								2,470	2,539						
		600						2,428							
								2,413	2,469						
								2,325	2,375						
								2,320	2,366						
								2,577	2,624						
								2,569	2,619						
								2,443	2,491						
		540						2,375	2,425	2,610	2,643	2,704	2,758		
													2,780		
													†2,805		
								2,419	2,476						
								2,335	*2,390						
								2,418							
								2,360							
								2,438							
								2,399							
								2,437							
						1,522									
								2,338							
								2,355	2,420						
								2,370	2,425						
								2,444	2,502						
								2,352	2,398						
								2,121							
								2,300	2,350				2,692		
		320		1,190	1,420	1,470	1,940	2,159	2,204						
		390		1,300	1,500	1,520	1,950	2,215	2,260						
						1,790									

Depths, in feet, to coals and principal

[From records furnished by the owners. *Signifies that the figures given represent the depths of gas by level. All other elevations

No. on Pl. I.	Elevation.	Name of well.	Owner.	Product.	Producing sand.
		South Strabane Township—Continued.			
213	1,495	Quail, No. 1	Quail Oil Co	Dry	
214	1,100	Quail (2d), No. 2	McKeown Oil Co	Oil	Fifty-foot
215	1,070	Alvin M. Smith, No. 1	Chartiers Oil Co	do	Gantz
216	1,060	Alvin M. Smith, No. 2	do	do	do
217	1,280	Alvin M. Smith, No. 3	do	do	do
218	1,290	Alvin M. Smith, No. 4	do	do	do
219	1,070	Alvin M. Smith, No. 5	do	do	do
220	1,192	Alvin M. Smith, No. 6	do	do	do
221	1,125	Alvin M. Smith, No. 7	do	do	do
222	995	W. J. Smith, No. 2	Forest Oil Co	Dry	
223	1,230?	W. W. Smith, No. 1(?)	do		
224	1,175	W. W. Smith, No. 4	do	Gas	Fifth
		Mary Stewart, No. 1	do	Oil	Gantz
225	1,120	J. R. Taylor, No. 1	do	do	
226	1,159L	M. Taylor, No. 1	do	do	Gantz, Fifty-foot.
227	1,250	M. Taylor, No. 2	do	do	do
228	1,325L	M. Taylor, No. 3	do	do	do
229	1,280	M. Taylor, No. 4	do	do	do
230	1,225	M. Taylor, No. 5	do	do	Gantz
231		M. Taylor, No. 6	do	do	do
232	1,280	M. Taylor, No. 7	do	Gas	Bayard
233	1,300	Wade, No. 2	Akins Bros	Oil	Gantz
234	1,225	Washington Floral Co	Cameron Oil Co	do	Gantz, Fifty-foot.
235	1,155	Willetts, No. 1	Willetts Oil Co	do	Gantz
236	1,135	Willetts, No. 2	do	do	do
237	1,100	Willetts, No. 3	do	do	do
238	1,130	Willetts, No. 4	do	do	do
239	1,070	Willetts, No. 5	do	do	do
240	1,100	Willetts, No. 6	do	do	do
241	1,215	Willetts, No. 7	do	do	do
242	1,315	Willetts, No. 8	do	do	do
243	1,185	Willetts, No. 9	do	do	do
244	1,190	Willetts, No. 10	do	do	do
245	1,065	Willetts, No. 11	do	do	Big Injun
		Willetts, No. 12	do	do	Gantz
		Willetts, No. 13	do	do	do
		Willetts, No. 14	do	do	do
		Willetts, No. 15	do	do	do
		Willetts, No. 16	do	do	do
246	1,160	Willetts, No. 17	do	do	do
		Willetts, No. 18	do	do	do
		Willetts, No. 19	do	do	do
247	1,135	Willetts, No. 20	do	do	do
		Willetts, No. 21	do	do	do
		Willetts, No. 22	do	do	do
		Willetts, No. 24	do	do	do

sands in the Amity quadrangle—Continued.

or oil in the sand; † signifies known steel line measurement; L means that the elevation was determined were determined by aneroid barometer.]

Depth to—															
Waynesburg coal.	Mapletown coal.	Pittsburg coal.	Upper Freeport coal.	Salt sand.	Big lime.	Big Injun sand.	Thirty-foot sand.	Gantz sand.	Fifty-foot sand.	Gordon Stray sand.	Gordon sand.	Fourth sand.	Fifth sand.	Bayard sand.	Elizabeth sand.
		405						2,236	2,291		2,530		2,625		
								2,130	2,188½						
								2,142							
								2,121							
								2,340							
		510						2,362							
								2,130							
								2,263							
								2,198							
		505		1,293	1,605	1,671		2,375		2,540		2,650	2,735	2,890	
		536						2 964½	2,424						
		492						2,316	2,369			2,637	2,702		
		666						2,507							
		377						2,220	2,277	2,477	2,495	2,540	2,611		
		410						2,280	2,340						
								2,382	2,440						
								2,468	2,528						
		615						24,33	2,490						
								2,358	2,488						
								2,395	2,459						
								2,415	2,471		2,556	2,703	2,746	2,802	
								2,516	2,567						
280		622		1,530	1,700	1,760	2,270	2,440	2,480						
		450?						2,286							
		†400						2,230							
		†387						2,222							
		†400													
		†380						2,187							
								2,203							
								2,347							
								2,465							
								2,324							
								2,324							
								2,218							
								2,219							
								2,444							
								2,306							
								2,425							
								2,279							
								2,297							
								2,461							
								2,219							
								2,345							
								2,366							
								2,192							

Depths, in feet, to coals and principal

[From records furnished by the owners. * Signifies that the figures given represent the depths of gas by level. All other elevations

No. on Pl. I.	Elevation.	Name of well.	Owner.	Product.	Producing sand.
		South Strabane Township—Continued.			
248	1,100	Willetts, No. 25	Willetts Oil Co	Oil	Gantz
249	1,140	Willetts, No. 28	do	do	do
250	1,250	Workman, No. 1	Forest Oil Co	do	do
251	1,315	Workman, No. 2	do	do	do
252	1,110	R. D. Wylie, No. 1	Pew & Emerson		
253	1,040	R. D. Wylie, No. 1	Pew & Singleton		
		Union Township.			
		Henry Smith, No. 1	Chartiers Oil Co		
		Borough of Washington (also including East Washington and West Washington).			
254	1,060	Agnew, No. 1	Geo. Davis & Co. (?)		
255	1,060	Agnew, No. 2	do		
256	1,165	Culbertson	Murdock Baldwin Oil Co	Gas and oil	Gantz, Fourth
257	1,175	Richard Forest, No. 1	Loury Oil Co	Oil	Gantz
258	1,170	Richard Forest, No. 2	do		
	1,175	Richard & Joshua Forest, No. 1 (?).	Joshua Oil Co	Dry	
259	1,205	Robert Forest		Oil	Gantz
260	1,060	Harding	O. W. Akins	do	do
		Harding, No. 2	Akins Bros	do	do
		Harding, No. 3	do		
261	1,145	Mathew Linn	W. F. Borchers	Dry	
262	1,080	Lustic (?)	Akins Bros		
263	1,055	Morgan	do	Oil	Gantz
264	1,050?	Reed	do	do	do
265	1,055?	Reed	Associated Producers Co		
266	1,025?	Smith, No. 1 (?)		Gas	"Verner"
267	1,055?	Smith, No. 2 (?)		do	Fifth
268	1,025?	Smith, No. 3 (?)		do	Gantz
269	1,190	Wade, No. 3	Akins Bros	Oil	do
270	1,120?	Triangle well	Associated Producers Co	Gas and oil	
271	(?)	Wade, No. 4	Akins Bros	Oil	Gantz
272	1,150	Geo. Warrick, No. 1	Murdock-Baldwin Oil Co	Oil and gas	do
		West Bethlehem Township			
273	1,190	N. T. Clark, No. 2	Manufacturers' Light and Heat Co.	Gas	
		John I. Cleaver	Monongahela Natural Gas Co.	do	
	1,265?	Ola Crumrine (?)	Philadelphia Co	do	
274	1,000?	Drague, No. 1 (?)	Carnegie Natural Gas Co	do	
275	1,185	James Grable, No. 1	Monongahela Natural Gas Co.	do	

sands in the Amity triangle—Continued.

or oil in the sand; † signifies known steel line measurement; L means that the elevation was determined were determined by aneroid barometer.]

		Depth to—													
Waynesburg coal.	Maple town coal.	Pittsburg coal.	Upper Freeport coal.	Salt sand.	Big lime.	Big Injun sand.	Thirty-foot sand.	Gantz sand.	Fifty-foot sand.	Gordon Stray sand.	Gordon sand.	Fourth sand.	Fifth sand.	Bayard sand.	Elizabeth sand.
								2,218							
								2,192							
								2,546	2,600						
								2,539	2,593						
		217													
		280													
								1,906	1,930						
								2,277							
								2,305							
		510			1,600	1,625		2,316			2,591	2,640	2,703		
		515						2,318							
		515						2,322							
		234						2,053		2,280			2,412		
		540						2,321	2,372						
						1,697		2,271							
								2,354							
								2,390							
								2,272					2,661		
								2,275							
								2,259							
								2,285							
		265	860					2,147							
		450						2,270							
		430						2,248			2,515		2,631		
		425						2,245							
								2,395	2,445						
		355						2,160	2,295	2,421	2,444				
								2,370	2,418						
		495		1,430	1,590	1,625		2,300							
280		614		1,540	1,770	1,845	2,454	2,500	2,610		2,780	2,825	2,900	3,009	3,100
		260		1,160		1,500			2,260						
		205				1,444		2,148							
		345										2,360		2,567	2,687
		590		1,490		1,850	2,400	2,500	2,540		2,840			2,990	3,080

Depths, in feet, to coals and principal

[From records furnished by the owners. * Signifies that the figures given represent the depths of gas by level. All other elevations

No. on Pl. I.	Elevation.	Name of well.	Owner.	Product.	Producing sand.
		West Bethlehem Township—Continued.			
276	855	J. R. Hawkins, No. 1	Philadelphia Co	Gas	
277	1,090	Harvey Hill, No. 1	do	do	
278	1,075	Margaret Hill, No. 1	Manufacturers' Light and Heat Co.	Oil	
279	1,010	Stephen W. Hill, No. 1	do	Gas	
280	1,010	Tom. T. Hill	Philadelphia Co	Dry	
281	1,100	Uriah Hill heirs (Martha Zollars).	Monongahela Natural Gas Co.	Gas	
282	1,075	Wm. B. Hill, No. 1	do	do	
283	960	Isaac Horn, No. 1	Carnegie Natural Gas Co	do	
		J. N. Horn, No. 1	Chartiers Oil Co		
284	1,090	J. V. Knestric			
		Sarah E. Lacock, No. 1	Chartiers Oil Co		
285	1,000	J. C. Martin, No. 1	Manufacturers' Light and Heat Co.	Gas	
286	1 040	Frank McCarthy, No. 1	Monongahela Natural Gas Co.	do	
287	1,180	Mary McCarthy, No. 1	do	do	
288	1,060	Winnet McCarthy, No. 1	do	do	
289	1,160	Winnet McCarthy, No. 2	do	do	
290	1,295	W. McCosland, No. 1	Manufacturers' Light and Heat Co.		
291	1,170	Elizabeth Morton, No. 1	Monongahela Natural Gas Co.	Gas	
292	1,120	Elizabeth Morton, No. 2	do	do	
293	1,170	H. H. Richards, No. 1	Philadelphia Co	do	
294	1,140	Eli U. Ross, No. 1	Chartiers Oil Co	do	
295	960	Joseph Ross, No. 1		Dry	
296	1,260	Sam Ross, No. 1	Manufacturers' Light and Heat Co.	Gas	
297	1,040	John C. Sargent, No. 2	do		
298	1,190	Thompson	do		
299	1,135	Thompson & Seaman Coal Co., No. 1.	do	Oil	
300	870	W. H. Ulery, No. 1	Carnegie Natural Gas Co	Gas	Big Injun, Bayard
301	970	Effie Watson, No. 1	Philadelphia Co	do	Elizabeth
302	1,110	Wherry, No. 1	Carnegie Natural Gas Co	Dry	
303	895	John B. Wise, No. 1	Philadelphia Co	Gas	Bayard
304	905?	Mary S. Wise, No 2	do	do	
305	1,170	W. W. Worrells, No. 1	Monongahela Natural Gas Co.	do	
		West Pike Run Township.			
306	1,075	James M. Miller, No. 1	Greensboro Natural Gas Co.		
307	1,050	Peter Nickerson, No. 1	do	Dry	
308	1,210	S. F. Scott, No. 1	Fergus Oil Co		
309	1,050	Geo. Thompson, No. 1	Greensboro Natural Gas Co.		

sands in the Amity triangle—Continued.

or oil in the sand; † signifies known steel line measurement; L means that the elevation was determined were determined by aneroid barometer.]

Depth to—														
Waynesburg coal.	Mapletown coal.	Pittsburg coal.	Upper Freeport coal.	Salt sand.	Big lime.	Big Injun sand.	Thirty-foot sand.	Gantz sand.	Fifty-foot sand.	Gordon Stray sand.	Gordon sand.	Fourth sand.	Fifth sand.	Bayard sand.	Elizabeth sand.
.....	.....	270	.....	1,170	.....	1,505	.....	.....	.....	.....	.....	.....	2,622	2,757	2,790
.....	.....	495	.....	.....	.....	1,740	.....	.....	.....	2,495	.....	2,715	2,810	2,845	2,989
.....	.....	620	.....	.....	1,792	1,832	.....	2,522	.....	.....	.....	.....	.....	.....	.....
.....	.....	475	.....	1,405	1,660	1,720	.....	2,400	2,455	.....	2,635	.....	.....	2,875	2,941
.....	.....	458	.....	1,400	.....	1,668	.....	.....	.....	.....	.....	2,652	2,780	2,839	.....
.....	.....	567	1,162	1,490	.....	1,785	2,280	2,465	2,558	.....	.....	2,750	2,879	2,948	3,037
.....	.....	520	.....	1,465	.....	1,720	.....	2,430	2,500	2,650	2,715	2,790	.....	2,910	3,020
.....	.....	360	805	.....	.....	1,617	.....	.....	2,370	2,545	†2,579	? 710	2,769	2,860	.....
.....	.....	524	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	.....	380	.....	.....	.....	.....	.....	2,275	.....	.....	.....	.....	2,585	.....	.....
.....	.....	755	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
130	.....	454	.....	1,407	1,640	1,690	2,255	2,376	2,455	.....	.....	2,662	2,746	2,862	2,954
.....	.....	481	1,231	1,420	.....	1,715	2,310	2,395	2,445	.....	2,695	2,820	2,862	2,972	.....
.....	.....	645	.....	1,550	.....	1,875	.....	.....	2,635	.....	.....	.....	.....	3,025	3,137
.....	.....	485	.....	1,385	.....	1,735	2,295	2,395	2,425	.....	.....	2,635	.....	2,854	2,990
.....	.....	605	1,350	1,530	.....	1,830	.....	2,520	2,560	2,735	2,800	2,880	.....	2,993	3,087
.....	.....	585	.....	1,518	.....	1,720	.....	2,468	2,503	2,603	2,680	2,715	2,765	.....	.....
.....	.....	605	1,360	1,570	.....	1,850	.....	2,550	2,592	2,800	2,845	2,910	.....	3,000	3,105
.....	.....	520	.....	1,460	.....	1,785	2,365	2,450	2,520	.....	2,735	2,816	2,865	2,920	3,008
.....	.....	620	.....	1,580	.....	1,870	.....	.....	.....	.....	.....	.....	2,991	.....	3,117
.....	.....	423	.....	.....	.....	1t400	.....	2,300	2,335	.....	.....	.....	.....	.....	.....
50	.....	365	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	.....	542	.....	1,480	1,655	1,715	2,300	2,434	2,469	2,585	2,612	2,644	2,723	.....	.....
180	.....	520	.....	1,435	1,665	1,730	.....	2,375	2,495	2,680	2,725	2,790	2,840	2,922	2,991
.....	.....	495	.....	1,492	.....	.....	.....	.....	2,422	.....	.....	.....	.....	.....	.....
240	.....	580	1,170	1,500	1,732	1,795	2,405	2,485	.....	.....	.....	.....	.....	.....	.....
.....	.....	290	.....	.....	1,480	.....	.....	.....	.....	.....	.....	.....	.....	2,760	.....
.....	.....	396	.....	.....	.....	1,632	.....	.....	.....	.....	2,375	.....	2,748	2,790	2,883
.....	.....	475	.....	.....	1,557	1,655	2,180	.....	2,410	.....	.....	.....	.....	.....	.....
.....	.....	290	.....	.....	.....	1,525	.....	.....	.....	.....	2,485	.....	.....	2,759	.....
.....	.....	338	.....	.....	.....	1,577	.....	.....	.....	.....	2,520	.....	2,641	2,727	2,817
.....	.....	615	.....	1,414	.....	1,865	2,425	2,525	2,555	.....	2,733	.....	.....	2,994	3,114
.....	.....	355	.....	.....	1,490	1,575	2,190	2,260	2,304	.....	.....	.....	.....	.....	.....
.....	.....	259	865	.....	1,412	1,497	.....	.....	.....	.....	.....	.....	.....	.....	.....
170	.....	516	1,090	.....	.....	1,750	.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	.....	.....	.....	.....	.....	1,490	.....	2,210	2,250	.....	.....	.....	.....	2,660	.....

COAL.

GENERAL STATEMENT.

Coal is destined to become the most important mineral resource of the Amity quadrangle. Owing to the depth of the principal seam below the surface, only a few mines are in operation at the present time, but the demand for coal is increasing with its exhaustion near the surface, and in time shafts will be sunk over much of the quadrangle and operations conducted on a large scale.

The principal coal beds outcropping in the quadrangle are the Pittsburg, Redstone, Sewickley (Mapletown), Waynesburg, Waynesburg "A," and Washington. The Pittsburg bed is the only one mined for shipment, but the Waynesburg is worked at many country banks, and one bank is known on the Redstone and several on the Sewickley seam. The Waynesburg "A" is probably worthless and the Washington coal is generally too poor to be of value under existing conditions. Several seams below the Pittsburg have been penetrated by the drill in search of oil and gas.

PITTSBURG COAL.

GENERAL STATEMENT.

The Pittsburg coal is the most valuable bed in southwestern Pennsylvania. From all the evidence obtainable it seems to be of workable thickness throughout the quadrangle and its quality is usually superior to that of the other coals of the region. The Pittsburg coal occurs at the base of the Monongahela formation, or Upper Productive Measures. (See columnar section, Pl. I, pocket.) Fig. 4 shows the total areal extent of the seam in Pennsylvania, together with the relative location of the Amity quadrangle. In this quadrangle the outcrop of the bed is only about 15 miles in length, but with the exception of the two small areas where it is cut by Chartiers and Peters creeks it is believed to underlie the entire district, a total area of 228 square miles. The average workable thickness of the bed being estimated at 6 feet and the specific gravity of Pittsburg coal in this region as 1.29,[a] the quadrangle contains 37,260,710,400 cubic feet,or 1,500,632,315 short tons (about 1,300,000,000 long tons). The coal has been estimated to underlie 833 square miles out of the total area of 858 square miles in Washington County.

The extent of the Pittsburg coal outcrop is shown on the geologic map (Pl. I, pocket) by the blue line at the contact of the Conemaugh and Monongahela formations. The outcrop of the coal follows both sides of Peters Creek below Venetia and of Chartiers Creek below McGovern, and the bed also reaches the surface at Meadowlands, where it out-

[a] The figure 1.29 is an average of the specific gravity of coal from three mines in the region, determined by the fuel-testing plant of the United States Geological Survey at St. Louis, Mo.

crops at railroad level. Well records show that the bed is present in all parts of the quadrangle. West of Chartiers Creek it reaches nearly a mile up the tributary valleys between Meadowlands and Houston. On Peters and Chartiers creeks it can be developed by drifting, but in the greater part of the quadrangle it is far below the surface and can be reached only by shafts. At Washington it is about 450 feet below the valley, at Linden 250 feet, at Wylandville 350 feet, at Lone Pine 350 feet, at Ellsworth 270 feet, at Zollarsville 350 feet, at Sunset 550

FIG. 4.—Map showing area of the Pittsburg coal bed in Pennsylvania.

feet, at Hackneys 500 feet, and at Tenmile village 400 feet. The method by which the approximate depth of this bed can be determined from the map is explained under the heading "Structure" (pp. 36–37), and its variation in level beneath the quadrangle is shown on the geologic map (Pl. I, pocket).

MINING OPERATIONS.

In the Amity quadrangle there are 13 working mines, as follows: Ellsworth Nos. 1, 2, 3, and 4, Manifold, Meadowlands No. 1, Rich Hill,

Allison, Boon, Blanche, Eclipse, Anderson No. 2, and Nottingham. The Manifold and Ellsworth mines are operated by shafts, Rich Hill and Meadowlands by slopes, and the rest by drifts. In addition to those named, the Enterprise mine, north of Washington, was formerly operated by a slope on the south side of Chartiers Creek and a 150-foot shaft at a point midway between the slope and Washington, but this mine is now abandoned. On the northwest bank of Chartiers Creek are situated the Rich Hill mine of the United Coal Company, the Meadowlands No. 1 of the Meadowlands Coal Company, and the Allison of the Pittsburg Coal Company. These mines are working a large area in Chartiers Township. The Boon mine at Canonsburg, the mouth of which is off the quadrangle northeast of Houston, also reaches inside the area. One mile south of Meadowlands, on a spur of the Pennsylvania Railroad recently built to it, is situated the Manifold mine, operated by the Patterson & Robbins Coal Company. Here two shafts have been sunk to the coal, 236 and 231 feet deep, respectively.

In the northeast corner of the quadrangle, on Peters Creek, are located the Blanche, Nottingham, and Eclipse mines of the Pittsburg Coal Company. These are operated by drifts. The old Anderson mine is located here, but is now abandoned. The Anderson No. 2 is being operated south of the creek.

On Pigeon Creek above Bentleyville are collieries Nos. 1, 2, 3, and 4 of James W. Ellsworth & Co. The coal is here deep below the surface and is reached by two shafts at Ellsworth and two at the village of Three and Four, 2½ miles farther up the creek, on South Branch. The shafts are 261, 279, 397, and 414 feet deep, respectively. This company is carrying on extensive operations and has built up-to-date plants and mining towns. Coal is shipped by means of a branch of the Pennsylvania Railroad running down Pigeon Creek and connecting with the main line at Monongahela City.

Opposite the Chestnut street station of the Pennsylvania lines at Washington a shaft was sunk many years ago to the Pittsburg bed. The coal was reported to be of excellent quality, but the shaft was abandoned on account of the extra expense involved in sinking the escape shaft.

THICKNESS.

The following table shows the average thicknesses of the coal in the various mines, together with the maximum and minimum measurements in each mine, in inches:

Thickness, in inches, of Pittsburg coal in the Amity quadrangle.

Mine.	Thickness.		
	Average.	Greatest.	Least.
Eclipse	62	64	60
Nottingham	57	60	54
Blanche	72	78	66
Boon	64	.....	.....
Allison	64	.....	.....
Meadowlands	64	.....	.....
Rich Hill	64	.....	.....
Ellsworth No. 1	72	74	70
Ellsworth No. 2	71	74	68
Ellsworth No. 3	73	76	70
Ellsworth No. 4	73	76	70

In the course of the field work several detailed sections were measured in various parts of the area. These measurements are given graphically in Pl. V. Except in a few places the bed is double, separated by a fire-clay parting of varying thickness. Here and there a third division is present, and in many places the bed is interrupted by other clay partings, but generally these are not persistent.

The roof division or portion above the clay parting is variable. In thickness it runs from 1 inch up to 4 feet. In some places it consists of a single bench, but more commonly is broken up into two or more benches, separated by shale or clay. The coal of this division is usually poor, containing a large proportion of ash.

The main clay separating the roof and lower divisions varies from a fraction of an inch up to 15 inches in thickness. The lower division of the Pittsburg coal varies in thickness from 3½ feet to 5 feet 10 inches and is the portion of the coal mined throughout this section of the field. The most characteristic feature of this division consists of two very persistent partings, which, as a rule, occur 2 to 3 feet from the bottom. They are known as the "bearing-in bands," and with the coal between them make up the "bearing-in coal." In few places are they over half an inch thick; commonly they are considerably thinner. The interval between them varies from 1 inch to 2½ inches. The name "bearing-in" has been applied because this bench is chosen by the miner as the easiest layer on which to work to undercut the overlying coal. The bearing-in coal is thrown out in mining. The bench is represented in all but two of the sections in Pl. V, and is probably present in the others, but was overlooked in taking measurements. In one country bank (section 5) the place of this bench is taken by fire clay. The bearing-in coal separates the lower division of the Pittsburg coal into two portions, the upper of which is known as the breast coal and the lower as the brick coal and bottom

coal. The names applied to various portions of the Pittsburg coal are shown graphically in fig. 5.

In most regions the brick coal and bottom coal are distinct, separated by a thin binder, but in this quadrangle they can generally not be distinguished. In only one or two instances are other binders noted below the bearing-in coal, but in several cases nonpersistent binders have been noted above it.

The greatest thickness of coal known in the quadrangle is that recorded in the Moses Smith drill hole near Bissell, West Bethlehem Township, as shown in the following section (Pl. V, No. 1):

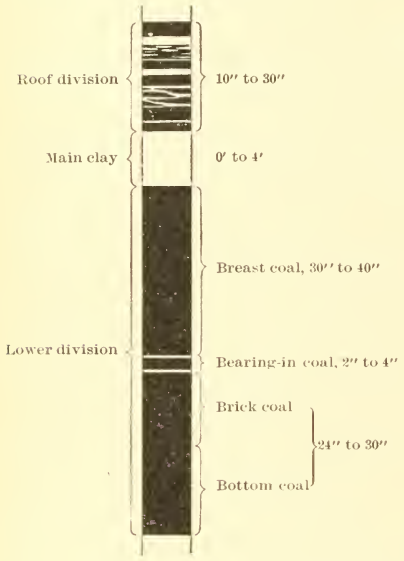


FIG. 5.—Generalized section of Pittsburg coal bed, with names of the various benches.

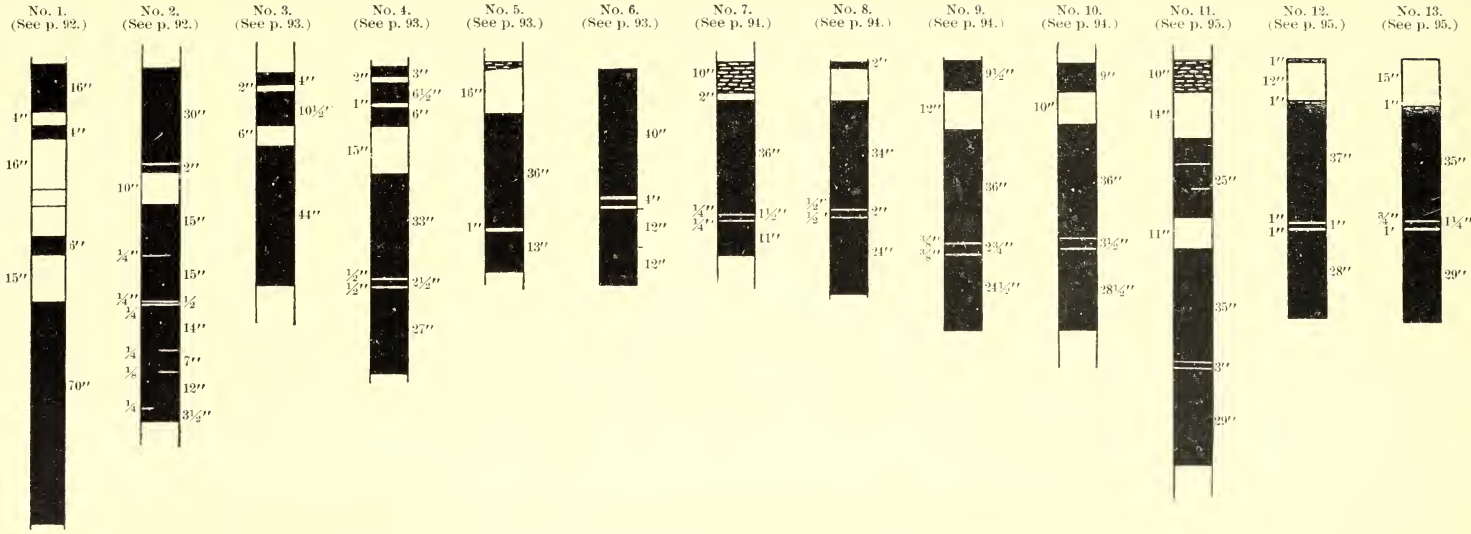
Section of Pittsburg coal near Bissell.

	Ft.	in.	Ft.	in.
Slate, black.				
Coal	1	4		
Slate, black				4
Coal		4		
Fire clay				5
Slate, black			1	4
Coal		6		
Slate			1	3
Coal, breast and *bottom*	5	10		
Slate, bottom.				
Total coal	8			

Sections 2 to 9, inclusive, Pl. V, show the characteristics of the coal in various parts of Chartiers Valley. The lower division in this valley is from 4 feet 2 inches to 5 feet 10 inches thick, the main clay from 2 to 22 inches. The upper division runs from 2 inches to 2½ feet and varies from clean coal to very bony. The bearing-in bands occur a little below the middle of the lower division. Local thin partings occur in all the mines, and therefore when a published section of the coal shows a parting other than those noted above it must be regarded as exceptional and not representing general conditions. The measurements of the known sections in Chartiers Valley are as follows:

Coal section at the Manifold mine (Pl. V, No. 2).

	Ft.	in.
Coal	2	6
Shale		1
Coal		2
Fireclay		10
Coal	1	3
Binder		¼



SECTIONS OF PITTSBURG COAL IN AMITY QUADRANGLE.

Scale, 1 inch to 5 feet.

Coal section at the Manifold mine—Continued.

		Ft.	in.
Coal		1	3
Bearing-in coal	Binder		¼
	Coal		½
	Binder		¼
Coal with several thin binders		3	2
		9	4¼

Coal section at "McLain's bank," 0.9 mile west of Meadowlands (Pl. V, No. 3).

	Ft	in.
Shale roof		
Coal		4
Shale		2
Coal		10½
Fire clay		6
Coal	3	8
	5	6½

Coal section at the Meadowlands mine (Pl. V, No. 4).

	Ft.	in.
Coal		3
Shale		2
Coal		6½
Shale		1
Coal		6
Shale and fire clay	1	3
Coal	2	9
Bearing-in coal: Parting		½
Coal		2½
Parting		½
Coal	2	3
	8	1

Coal section 1.3 miles north of Meadowlands (Pl. V, No. 5).

	Ft.	in.
Bony clay		2
Fire clay	1	4
Coal	3	
Fire clay		1
Coal	1	1
Fire clay		
	5	8

Coal section at the Allison mine (Pl. V, No. 6).

[Second Geol. Survey Pennsylvania: Rept. K, p. 235.]

	Ft.	in.
Coal	3	4
Bearing-in coal		4
Brick coal	1	
Lower bottom coal	1	
	5	8

Coal section 0.5 mile south of Houston (Pl. V, No. 7).

		Ft.	in.
Bony coal			10
Fire clay			2
Coal		3	
Bearing-in coal	Clay		¼
	Coal		1½
	Clay		¼
Coal			11
Fire clay.			
		5	1

Coal section 0.3 mile east of Houston (Pl. V, No. 8).

		Ft.	in.
Sandy shale.			
Coal			2
Fire clay			10
Coal		2	10
Bearing-in coal	Parting		½
	Coal		2
	Parting		½
Coal		2	
		6	1

Coal section reported at Boon mine, northeast of Houston (Pl. V, No. 9).

		Ft.	in.
Coal			9½
Clay			1
Coal		3	
Bearing-in coal	"Slate"		⅜
	Coal		2¾
	"Slate"		⅜
Coal		2	½
		6	2½

On Peters Creek the thickness of the lower division is 5½ to 6 feet and of the upper division 6 to 12 inches. The clay averages a little less than a foot in thickness. In the Nottingham mine a still higher bench is reported, 14 inches above the upper division; but this topmost bench is very bony. Two sections measured in this district are as follows:

Coal section at the Blanche mine (Pl. V, No. 10).

	Ft.	in.
Roof coal		9
Fire clay		10
Coal	3	
Bearing-in coal		3½
Coal	2	4½
	7	3

Coal section at the Nottingham mine (Pl. V, No. 11).

	Ft.	in.
Coal and bone		10
Fire clay and shale	1	2
Coal with thin partings	2	1
Fire clay		11
Coal	2	11
Bearing-in coal		3
Coal	2	5
	10	7

At the Ellsworth the average thickness of the lower division of the coal is about 6 feet. Two typical sections measured as follows:

Coal sections at the Ellsworth Collieries (Pl. V, Nos. 12 and 13).

		Ellsworth No. 1. Ft.	Ellsworth No. 1. in.	Ellsworth No. 2. Ft.	Ellsworth No. 2. in.
Bony coal			1		
Fire clay		1		1	3
Bony coal			1		1
Coal		3	1	2	11
Bearing-in coal	Shale		1		¾
	Coal		1		1¼
	Shale		1		1
Coal		2	4	2	5
		6	10	6	11

QUALITY.

In quality the Pittsburg bed in Washington County is fair for a bituminous coal. During the field work for this report a number of samples of the coal were taken and sent for analysis to the fuel-testing plant of the United States Geological Survey at St. Louis. Each one of these samples was obtained by cutting a section 2 inches thick from roof to floor across as much of the seam as is mined for shipment, all partings not included by the miner being thrown out. The sample was then thoroughly mixed and quartered to the bulk desired, sealed in an air-tight can, and mailed to the chemical laboratory at St. Louis.

All analyses of the Pittsburg coal given here include only the lower division, or portion mined for shipment. The bearing-in coal is excluded, as it is generally thrown out in mining.

Analyses of Pittsburg coal on Chartiers and Peters creeks.

[E. E. Somermeier, analyst.]

	1.	2.	3.	4.
Moisture	1.90	1.37	1.70	1.72
Volatile matter	36.20	37.10	37.20	36.98
Fixed carbon	53.70	53.84	55.83	56.55
Ash	8.20	7.69	5.27	4.75
	100.00	100.00	100.00	100.00
Sulphur	1.52	1.61	1.13	1.15
Calories			7,964	
British thermal units			14,335	

1. McLain's country bank, near Meadowlands.
2. Manifold mine, south of Meadowlands.
3. Blanche mine, Peters Creek.
4. Nottingham mine, Peters Creek.

These four analyses show a fair agreement. The fixed carbon and sulphur are moderate and the ash is low, but more variable.

At the Ellsworth collieries four samples have been taken, the first from each mine being taken by the writer of this report and the second from each mine by Messrs. Groves and Von Borries, of the fuel-testing plant.

Analyses of Pittsburg coal from the Ellsworth collieries.

[E. E. Somermeier, analyst.]

	No. 1.		No. 2.	
Loss of moisture, air dried		1.50		1.50
Moisture	1.22	2.91	1.05	3.01
Volatile matter	36.28	33.70	36.65	33.46
Fixed carbon	56.24	57.99	57.25	58.70
Ash	6.26	5.40	5.05	4.83
	100.00	101.50	100.00	101.50
Sulphur	.84	1.08	.91	.73
Calories				7,915
British thermal units	14,247			14,197

These analyses show an improvement on the quality of the coal farther north and west. It is fairly low in sulphur and averages slightly higher in fixed carbon. The proportion of ash averages about the same. This coal would seem to be worth coking.

The average composition of the coal in the quadrangle, based on the foregoing eight analyses, is as follows:

Calculated average composition of Pittsburg coal in the Amity quadrangle.

Moisture	1.86
Volatile matter	35.95
Fixed carbon	56.26
Ash	5.93
	100.00
Sulphur	1.12

In a report on "run of mine" made to James W. Ellsworth & Co., by Doctor Bogdahn, chief chemist of the United Coke and Gas Company, Otto, Allegheny County, Pa., analyses of dry coal and of crucible-made coke from the Ellsworth mines are given. The compositions were as follows:

Analyses of dry coal from Ellsworth collieries and of coke made in a crucible from the same coal.

	Coal.	Coke.
Volatile matter	37.92	1.08
Fixed carbon	57.72	92.35
Ash	3.69	5.96
Sulphur	.67	.61
	100.00	100.00
Phosphorus	.0032	.0051

A comparison of this coal analysis with those on page 96 made by the United States Geological Survey shows lower ash and sulphur than the other samples, indicating that this is probably picked coal and that the analysis may be taken as representative of the best coal in the quadrangle.

In addition to these analyses, several others have been gathered from miscellaneous sources and are given in the following table. In several cases where analyses were made years ago it is not known whether or not the locality is inside the quadrangle, but the name of the township indicates the probability that it is within the area or close to its borders.

Analyses of Pittsburg coal from the Amity quadrangle and vicinity.

	1.	2.	3.	4.	5.	6.	7.	8.
Moisture	0.775	1.095	1.010	1.540	1.080	1.425	.....	.....
Volatile matter	36.770	39.790	40.995	37.825	40.350	36.880	30.75	32.75
Fixed carbon	51.467	55.033	48.769	57.063	50.311	56.829	59.98	55.51
Ash	8.890	2.910	7.020	2.810	5.665	4.070	8.37	10.76
Sulphur	.....	1.172	2.206	.726	2.594	.796	.89	98
Phosphorus	.....	.....	.....	.....	.....	.....	.01	.005
	97.902	100.000	100.000	99.964	100.000	100.000	100.00	100.005
Coke	62.455	59.115	57.995	60.365	58.570	61.695	.....	.....
Color of ash	.....	.....	Red.	.....	Red.	Cream.	.....	.....

1. Patterson's bank, East Bethlehem Township. This includes only the "roof coal." (Stevenson, J. J., Second Geol. Survey Pennsylvania, Rept. K, 1876, p. 381; analyzed by D. McCreath.)
2. T. Thompson's bank, Chartiers Township. (Loc. cit.; analyzed by D. McCreath.)
3. P. Ashurst's bank, Chartiers Township. (Loc. cit., analyzed by D. McCreath.)
4. Harding and Warrick, South Strabane Township. (Loc. cit., analyzed by A. S. McCreath.)
5. Peters Township. (Loc. cit.; analyzed by A. S. McCreath.)
6. Liddell's bank, East Bethlehem Township. (Loc. cit.; analyzed by A. S. McCreath.)
7. Moses Smith diamond-drill hole, West Bethlehem Township; "breast coal" only. (James W. Ellsworth & Co.; analyzed by Wuth & Stafford, Pittsburg.)
8. W. H. Ulery diamond-drill hole, West Bethlehem (?) Township; "breast coal." (James W. Ellsworth & Co.; analyzed by Wuth & Stafford.)

From these analyses it will be seen that the sulphur is one of the most variable constituents of the Pittsburg coal in this quadrangle. In the northern and western parts of the area it seems to be generally moderate, but in one instance in Peters Township it runs as high as 2.594 and at one bank in Chartiers Township it reaches 2.206, according to the Second Geological Survey. The present survey makes the maxima 1.15 and 1.61 in these districts. It is improbable that the coal will be of much value for gas or coking in those portions of the quadrangle, unless the sulphur can be reduced by washing to less than 1 per cent; but it ought to be a first-class steam coal.

Samples from the Ellsworth mines and Nos. 6, 7, and 8 of the table from the southeastern quarter of the quadrangle show sulphur ranging from 0.67 to 0.98, indicating a better quality in this direction. It seems probable that in time the coal may be coked in this portion of the quadrangle. In general it may be said that the quality of the Pittsburg coal improves toward the east and deteriorates westward from the quadrangle, becoming poorest in Ohio.

METHODS OF DEVELOPMENT.

As the Pittsburg coal in this quadrangle outcrops in only two localities where it is now mined, it must be developed principally by shafts, as has been done by the Ellsworth Company on Pigeon Creek. This company has sunk shafts at two localities near the bottom of the Waynesburg syncline, thus taking a position where the mines may be easily drained by the natural inclination of the coal to the foot of the shaft, from which the water may be pumped to the surface. As the valley of Pigeon Creek has gentle grades, it has been a simple matter to connect the mines with the Monongahela branch of the Pennsylvania Railroad by a line running to Ellsworth. Between Three and Four and the crest of the Amity anticline is an area 3 miles broad along South Branch of Pigeon Creek, 3½ miles broad on Center Branch, and 4 miles broad on North Branch of Pigeon Creek, in which the dip is toward the southwest. This gives a large area in which the Pittsburg coal can be advantageously mined by shafts sunk on the main branches of Pigeon Creek. Short switches will connect with the Ellsworth branch railroad.

On Peters Creek in the northeast corner of the quadrangle most of the mines are rather unfavorably situated in relation to the structure, as their proximity to the crest of the Amity anticline makes it necessary to mine down the dip. A more satisfactory method of developing the coal lying between Peters and Mingo creeks would be to sink shafts along Mingo Creek near the edge of the quadrangle and mine northward up the dip as far as the limit of the Peters Creek workings and westward as far as the crest of the anticline, which crosses Mingo Creek near Kammerer. Near the edge of the quad-

rangle a shaft less than 100 feet deep would reach the coal. The railroad might even be continued 3 miles or so beyond this to the source of the Mingo Creek drainage, and in the area between Gilkeson and Kammerer shafts could be sunk and operations pushed east and northeast up the dip to meet the workings on the eastern flank of the axis. A small area south of Mingo Creek could also be opened up from the shafts along its course, but as the Amity anticline pitches to the southwest, most of the region lying south of the Williamsport pike can probably be more economically worked from shafts located on North Branch of Pigeon Creek.

At the point where the axis of the Nineveh syncline crosses Little Chartiers Creek, near Linden, the Pittsburg coal lies between 200 and 250 feet below the surface, and this is probably the most favorable location in this valley for a shaft. From it a large area both east and west of the syncline can be mined and easily drained, and the coal can be conveniently hauled by connecting with the Baltimore and Ohio Railroad at Gambles or with the Pennsylvania lines near Morganza, 3½ miles to the north.

Probably the next favorable point in the valley of Little Chartiers Creek for sinking a shaft lies on the axis of the syncline one-half mile west of Clokeyville station. The depth of shaft necessary to reach the coal will be about 400 feet, but as the mine would be situated on the main line of the Baltimore and Ohio Railroad no branches would be necessary. From this point the coal can be mined up the dip in every direction except toward the south. The area lying between Mount Pleasant and Clokeyville can probably be best developed by sinking a shaft at the head of the small valley about 1 mile west of Mount Pleasant. The depth to the coal here is supposed to be between 600 and 650 feet.

In order to develop the coal in the southern half of the quadrangle a railroad must be built into the valley of Tenmile Creek. The line can be connected with the Monongahela branch of the Pennsylvania Railroad at West Brownsville, about 18 miles below Zollarsville, with the Ellsworth branch by tunneling from Daniels Run to South Branch of Pigeon Creek, or with the Baltimore and Ohio Railroad by a branch line ascending Little Chartiers Creek south of Eightyfour and descending Brush Run to Lone Pine, whence branches could be run both up and down stream.

In the valley of Tenmile Creek and its tributaries many favorable points for shafts can be found. The axis of the Waynesburg syncline crosses Daniels Run 1½ miles from its mouth and Tenmile Creek three-fourths of a mile below Bissell, and shafts at these points ought to reach the coal at about 380 and 470 feet, respectively. From such shafts entries could be driven to the north, east, and west; but as the Waynesburg syncline is here pitching toward the south, the coal south

of Tenmile Creek can probably be taken out better from a somewhat deeper shaft sunk near the head of Patterson Run or on Craig Run or Craynes Run in Greene County. Most of the coal in the borough of Deemston can be mined from shafts which will doubtless be sunk on Plum Run, along which the depth of the coal varies from 190 feet at the mouth of the run to 430 feet near its head. Below Plum Run on Tenmile Creek the coal approaches the surface. It is probable that the eastern part of the borough of Deemston can be best developed from the heads of the valleys in the vicinity of Deemston. The depth of shaft necessary in the two valleys west of Deemston will be about 350 feet and on Fishpot Run east of Deemston 250 to 300 feet, according to exact location.

In the southwestern quarter of the quadrangle almost any point along Tenmile or Little Tenmile Creek or their larger tributaries is suitable for shaft locations, but no shaft should be sunk within a mile or so of the point where the Amity anticline crosses Tenmile Creek 1½ miles east of Hackneys. Along this creek between Bissell and Hackneys the coal will probably be reached between 440 and 480 feet below the surface; and mining can be conducted with good drainage in every direction except toward the south. The area south of the creek can probably be best developed by working northward from near the heads of Craynes and Boyd runs and Ruff Creek in Greene County, thus working up the dip.

On Bane Creek the coal descends from 450 feet below the surface at its mouth to about 720 feet in the bottom of the Nineveh syncline near McCracken station. Between Hackneys and Sunset workings can be carried east of the creek to the limit of a profitable haul, but as the strike here is about parallel to the creek, the area west of the creek should be mined from shafts situated farther west, in some of the side valleys. Above Sunset the strike of the rocks is more nearly at right angles to the creek and hence mining can be conducted both east and west of the creek in this part of the area. A shaft about 700 feet deep sunk on the axis of the syncline near McCracken could mine in all directions with every advantage. By referring to the map it will be seen that the Waynesburg and Washington Railroad follows Bane Creek northward from Hackneys to its source and thence climbs over the hills to Washington. This railroad is a narrow-gage line with steep grades and hence can not now be used for hauling coal; but if it should be rebuilt on a broad gage and connected with the Monongahela Valley by way of Tenmile Creek, it would furnish an outlet for the coal in this region.

On Little Tenmile Creek the coal is nearest the surface near Lone Pine, where its depth is about 330 feet. From this point the bed descends in both directions to about 470 feet below the surface at the

mouth of the Creek and probably about 630 feet below the surface in the bottom of the Nineveh syncline along the creek northwest of Lowland. No shafts should be sunk near Lone Pine, as this place is on the axis of the anticline, but a favorable locality for operations would be at the mouth of Potato Run or Shipe Run, 1 to 1½ miles above Lone Pine, or about the same distance downstream. At the mouth of Shipe Run the coal is believed to lie about 400 feet deep and below Lone Pine it is known by a well record to be within 340 feet of the surface. Perhaps this is the most favorable locality for operations on Little Tenmile Creek, but owing to the deflection in the strike of the beds here economical operations can be carried on only to the northeast, north, and west. The greatest area of most profitable mining can be obtained by sinking shafts on the Nineveh axis in any of the small valleys above Lowland.

In developing the coal of any section the location and direction of operations will necessarily be guided by the boundaries of the land controlled by various companies and individuals, and the conditions influenced by such control must be met accordingly. After the coal has been "mined out" in the most favorable areas, intervening unworked tracts will remain, the development of which must be undertaken according to various local conditions. It is probable that within one hundred years little Pittsburg coal will remain in this region.

In case the Upper Freeport coal is proved to be of value, this bed can be mined in connection with the Pittsburg seam, by sinking the shafts 600 feet deeper.

REDSTONE COAL.

The next bed above the Pittsburg is the Redstone, which in the Monongahela Valley is a coal of some importance. It is a promising bed in the northeastern part of this quadrangle, but in other portions of the area it is little known.

THICKNESS.

The Redstone coal lies from 20 to 80 feet above the Pittsburg seam. At several points in the vicinity of Hackett and Finleyville it has been opened in country banks, and in one instance a thickness of 40 inches was measured, as shown in fig. 6, section 21. This was at a bank directly above the Nottingham mine. The interval to the Pittsburg seam here is 70 feet. This coal may possibly be the Sewickley, but the interval from the Sewickley to the Pittsburg is usually as much as 110 to 150 feet, and is rarely known to be less than 100 feet. About 2¼ miles northwest of Meadowlands a blossom of the Redstone occurs at an estimated interval of about 60 feet above the Pittsburg. Coal is reported in the Enterprise shaft, 20 feet above the Pittsburg bed and

75 feet below the Sewickley, but this may be the rider coal which is common throughout much of the Monongahela Valley. The reported thickness here is 2 feet 6 inches, and in the air shaft near by there is 4 feet of it.

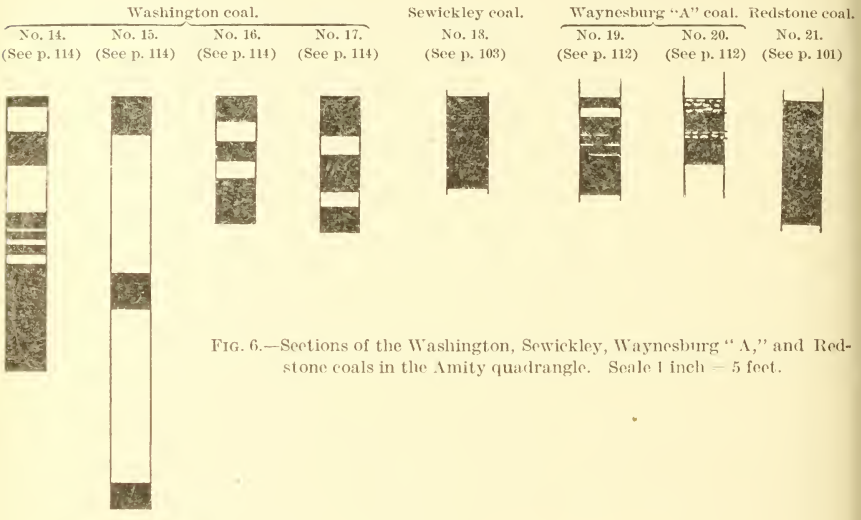


FIG. 6.—Sections of the Washington, Sewickley, Waynesburg "A," and Redstone coals in the Amity quadrangle. Scale 1 inch = 5 feet.

QUALITY.

One sample of the Redstone coal has been analyzed. It was taken from the bank above the Nottingham mine in the same way as the samples of the Pittsburg coal (see p. 95), and was analyzed at the fuel-testing plant at St. Louis. The composition is as follows:

Analysis of Redstone coal from country bank near Hackett.

Moisture	1.46	Sulphur	2.05
Volatile matter	35.56		
Fixed carbon	53.39		
Ash	9.59		
	100.00		

This analysis indicates a coal of fairly good quality, ranking the Redstone in this region next in value to the Pittsburg. The quantity of fixed carbon is high, the percentage of ash only slightly exceeds that in the Pittsburg, and the amount of sulphur is not extreme.

An analysis from I. Teeple's bank near Monongahela, east of the quadrangle, is given for comparison[a].

[a] Second Geol. Survey Pennsylvania, Rept. K, 1876, p. 379.

Analysis of Redstone coal from bank near Monongahela.

[A. S. McCreath, analyst.]

Moisture	1.060	Percentage of coke	65.350
Volatile matter	33.590	Color of ash, gray.	
Fixed carbon	48.688		
Ash	14.295		
Sulphur	2.367		
	100.000		

SEWICKLEY COAL.

The Sewickley coal is frequently reported in well records at distances varying from 100 to 150 feet above the Pittsburg coal and near the base of the Benwood limestone. To the drillers it is universally known as the "Mapletown coal," the name coming from Mapletown, Greene County, where the bed is mined. In some parts of Greene County it is a valuable coal, but in the Amity quadrangle little is known regarding it.

THICKNESS AND INTERVALS.

On Mingo Creek, near the boundary between Carroll and Nottingham townships, this coal has been opened at two country banks. A measurement at one of these gave 28 inches of clean coal, with a fireclay roof (fig. 6, section 18). This coal appears in blossoms at several points within a distance of 1½ miles up the main branch of this creek and 2½ miles up the run entering Mingo Creek from the northwest. At a number of points in the vicinity of Hackett and Finleyville a good coal has been opened at country banks 50 to 80 feet above the Pittsburg, and this may possibly be the Sewickley; it is, however, considered as more probably the Redstone. In the northwestern part of the quadrangle the Sewickley is extremely thin. In the Enterprise shaft only 3 inches was found, and in the Washington shaft it is missing.

The Sewickley coal is reported in a number of wells drilled in the quadrangle for oil and gas, and in order to show the intervals and thickness these are tabulated on the next page.

Data regarding Sewickley (Mapletown) coal as reported in drill records.[a]

No. on Pl. I.	Name.	Location.	Depth below surface.	Distance above Pittsburg coal.	Thickness.
			Feet.	*Feet.*	*Feet.*
56	Bristor, No. 3	Morris Township, Greene Co.		148	
122	James Thomas	Nottingham Township	230	102	5
	Horn heirs	Morgan Township	345	120	
24	A. B. Crumrine	Borough of Deemston	85	123	4
45	J. L. Thompson, No. 2	do	410	96	5
23	N. T. Clark, No. 1	do	315	105	6
31	Mrs. A. L. Hawkins, No. 1	do	298	127	
15	Luse	Borough of Bealsville	318	116	2
	Average			117	

[a] All measurements given in this report, unless otherwise stated, are from top to top of the respective beds.

QUALITY.

No analyses have been made of the Sewickley coal in the Amity quadrangle, but Stevenson in his report[a] gives three analyses from the southeastern part of Greene County. These are as follows:

Analyses of Sewickley coal from Greene County.

	1.	2.	3.
Moisture	1.790	1.500	1.088
Volatile matter	35.400	30.428	34.012
Fixed carbon	56.818	55.038	51.783
Ash	4.840	11.628	10.856
Sulphur	1.152	1.406	2.261
	100.000	100.000	100.000
Percentage of coke	62.810	68.072	64.960
Color of ash	Gray.	Red gray.	Red gray.

1. Dunkard Township. Analyzed by D. McCreath.
2. Near Mapletown, Monongahela Township; upper bench. Analyzed by S. A. Ford.
3. Near Mapletown, Monongahela Township; lower bench. Analyzed by S. A. Ford.

The proportion of ash is generally large, but the coal is reported to burn freely and to be marketable. In West Virginia it is a valuable coal.

UNIONTOWN COAL.

The Uniontown coal is a bed occurring at an average interval of 230 to 260 feet above the Pittsburg and 40 to 80 feet below the Waynesburg, just above a characteristic yellow limestone. It is present in many places as a distinct blossom, but is everywhere thin and is not persistent in this quadrangle.

[a] Second Geol. Survey Pennsylvania, Rept. K, 1876, p. 379.

WAYNESBURG COAL.

The Waynesburg bed is best developed in Greene County, but has a wide distribution. It can nearly always be recognized by the presence of a coarse, flaggy sandstone, 20 to 60 feet thick, which generally outcrops directly above. Although locally missing, this sandstone accompanies the coal over wide areas. In some places they are separated by a few feet of a black shale, but in this quadrangle the shale is more commonly absent.

INTERVALS.

The stratigraphic position of the Waynesburg coal is at the top of the Monongahela formation, at distances varying from 290 to 350 feet above the Pittsburg. This interval in a general way diminishes from Fayette toward western Washington County; but within the limits of the Amity quadrangle there seems to be no uniformity in variation in any particular direction. The minimum interval known is 292 feet in North Franklin Township, and the greatest is 355 feet in East Bethlehem Township; but intervals of 340 to 350 feet occur in South Strabane, Somerset, West Pike Run, and West Bethlehem townships, and in Morris Township, Greene County. The following table includes all available well records in the quadrangle in which the two coals are reported. The intervals are measured from the tops of the respective coals, and the thickness of the Monongahela formation can therefore be approximately determined in each instance by the addition of 6 to 10 feet for the thickness of the Pittsburg coal.

Distance between Pittsburg and Waynesburg coals in Amity quadrangle, as shown by drill records.

No. on Pl. I.	Name of well.	Location.	Distance.	Thickness of Waynesburg coal.
			Feet.	*Feet.*
3	Baker	Amwell Township	337	.....
	Moses Smith diamond drill	do	323	6
14	Mrs. A. L. Hawkins No. 2	Borough of Beallsville	333	3
15	Eaton Luse heirs No. 1	do	322	3
23	N. T. Clark No. 1	Borough of Deemston	330	4
32	Mrs. A. L. Hawkins No. 3	do	333	3
34	L. V. Martindale No. 2	do	330	4
44	J. L. Thompson No. 1	do	340	2
45	J. L. Thompson No. 2	do	356	5
46	J. L. Thompson No. 3	do	335	6
47	J. L. Thompson No. 4	do	337	4
48	J. L. Thompson No. 5	do	330	3
54	Blakely No. 1	East Bethlehem	355	.....
56	Bristor Bros. No. 3	Morris Township, Greene County.	345	.....
62	Elmas Carey No. 1	Morris Township, Washington County.	314	5
	Meloy No. 1	do	311	5
	J. C. Mounts	North Franklin Township	292	.....

Distance between Pittsburg and Waynesburg coals in Amity quadrangle, as shown by drill records—Continued.

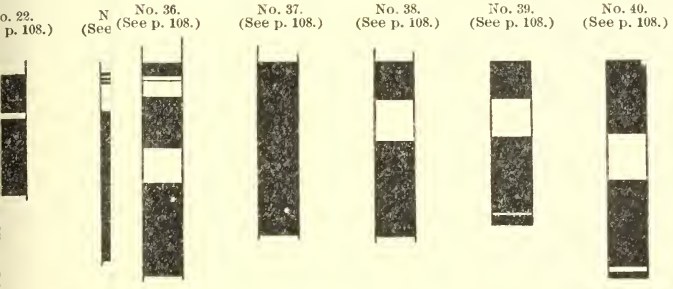
No. on Pl. I.	Name of well.	Location.	Distance.	Thickness of Waynesburg coal.
			Feet.	*Feet.*
234	Washington Floral Co	South Strabane Township	345	3
273	N. T. Clark No. 2	West Bethlehem Township	334	4
285	J. C. Martin No. 1	do	321	4
295	Joseph Ross No. 1	do	315	
297	John C. Sargent No. 2	do	340	5
299	Thompson and Seaman Coal Co. No. 1.	do	340	5
308	S. F. Scott No. 1	West Pike Run Township	346	
	Average		332	

DISTRIBUTION.

The outcrop of the Waynesburg coal horizon is shown on the geologic map (Pl. I, pocket) by the blue line at the contact of the Monongahela and Washington formations. The dash portion of the line indicates doubt whether the coal is workable and the dotted part shows places where it is probably too thin to be of value. It will be seen that over the northeastern quarter of the quadrangle the coal outcrops near the top of the hills. This is also true east of Zollarsville and south of Beallsville. Throughout these areas the bed seems to be uniformly present and has been opened at a great many country banks.

From Nottingham and Somerset townships toward Chartiers Creek, however, the seam decreases in importance. It outcrops over a considerable area in the valley of Little Chartiers Creek north of Eighty-four, and between Wylandville and the edge of the quadrangle several country banks have been opened at various times. The horizon follows the eastern side of Chartiers Creek high up on the hills, but in that district the coal is not known to be of value and may be absent in much of the area. In the Enterprise shaft, north of Washington, it is only 3 inches thick, and in the Washington shaft only 8 inches. At Lone Pine, where it is brought up by the Amity anticline, it shows for a short distance, and here it has been extensively mined at several country banks. With this exception the bed lies deep beneath the surface throughout the entire area south of Washington and Eighty-four and west of Odell and Zollarsville. The depth below creek level is about 200 feet at Sunset and 100 to 150 feet between West Amity and Ten-mile village.

The probable depth of the Waynesburg coal at any point in the quadrangle can be found by adding the corresponding interval (300 to 350 feet) to the elevation of the Pittsburg coal as shown by the structure contours and then subtracting the sum from the surface ele-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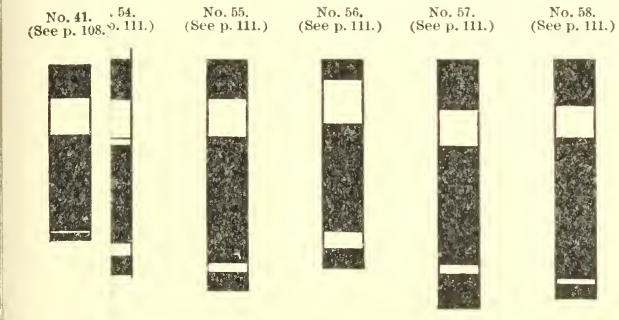
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No. 56.
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No. 57.
(See p. 111.)
No. 58.
(See p. 111.)

SECTIONS OF THE WAYNESBURG COAL IN THE AMITY QUADRANGLE.

Showing general persistence and variations of the three divisions and partings. Scale, 1 inch to 5 feet

vation at the point in question. The approximate interval to be added can be estimated in various portions of the quadrangle by means of the table on pages 105–106. Where no measurements have been made in the vicinity the average interval should be used.

THICKNESS.

In thickness the Waynesburg coal is variable, running from a few inches to 7 feet. Like the Pittsburg bed, it usually occurs in more than one bench, separated by clay partings. In general there are three persistent benches of coal. This is illustrated in Pl. VI. With few exceptions the upper fire-clay parting is persistent, with an average thickness of 1 foot, occurring in general a little nearer to the top than to the bottom of the seam. The bench directly below this is the one most commonly mined.

Along the several branches of Pigeon Creek many country banks have been opened on this bed, and these show sections varying from 3 to 7 feet in thickness (Pl. VI, sections 22 to 42). The table on the next page gives the exact measurements of these.

Detailed measurements of the Waynesburg coal in the valley of Pigeon Creek.[a]

No. of section on Pl. VI.	Location.	Reference.	Fire clay.	Coal.	Fire clay.	Coal.	Fire clay.	Coal.	Total.
			Ft. in.	Ft. in.	Ft. in.	Ft. in.	Ft. in.	Ft. in.	Ft. in.
22	Kammerer opening		(b)	1 2		2			3 2
23	2 miles southeast of Kammerer		(b)	[c] 3	[c] 9	3 11			4 11
24	0.8 mile southeast of Emery		[b] 1	1	1	2 6			5 6
25	0.8 mile northwest of Bentleyville			1	1	2 8	1	1 3	[d] 6 11
26	"A. Hetherington bank," North Branch Creek	Second Geol. Surv. Pa., Rept. K, p. 218.		11	1 1	[e] 2 7	2	1 2	5 11
27	"H. Myers bank," North Branch Pigeon Creek	do		1 3	1 2	2 10	5	1 4	7
28	"Couch bank," North Branch Pigeon Creek	do		1 2	1	2 10	6	1 3	6 9
29	"B. Emery bank," North Branch Pigeon Creek	Second Geol. Surv. Pa., Rept K, p. 219.		10	1 2	2 8	8	1 4	6 8
30	"Joseph Scott bank," 1 mile above Bentleyville	Second Geol. Surv. Pa., Rept. K, p. 217.		3	1 2	3	½	7	2 3½
31	"Shaner bank," near Bentleyville	do		1 2	1 2	1 10	2	1 6	5 8
32	"J. Huffman bank," Center Branch Pigeon Creek	do		10	1 3	3	½	1	6 1½
33	"J. J. Huffman bank," Center Branch Pigeon Creek	do		1	1	3 4	1	6	5 11
34	"Burger bank," Center Branch Pigeon Creek	do		1	1 3	3 6	2	2 2	8 1
35	0.3 mile southeast of Ellsworth		(b)	8	1 1	2+			3 9+
36	1.8 miles east-northeast of Scenery Hill			3½	7½	1 4	11	2 5	5 7
37	0.3 mile south of Vanceville (lower opening)							4 6	9 1+
38	0.3 mile south of Vanceville (upper opening)			1	1 1	2 6+			
39	"S. Tombaugh bank," South Branch Pigeon Creek	Second Geol. Surv. Pa., Rept. K, p. 148.		1	1	2	½	3	4 3½
40	"Whitfield bank," South Branch Pigeon Creek	do		1 11	1 3	2 3	2	2	5 9
41	"D. M. Letherman bank," South Branch Pigeon Creek	do		10	1	2 6	1	2	4 7
42	1.7 miles southeast of Vanceville		(b)	6	1 6	1 10			3 10

[a] See graphic representations on Pl. VI. [b] Sandstone rock. [c] With some fire clay. [d] Contains clay partings. [e] Slate.

In general these sections show a fair agreement, having a main bench and an upper bench ("roof coal"), separated by 6 to 18 inches of fire clay. The "roof coal" varies in thickness from 3 to 23 inches, the main bench from 22 to 47 inches. The maximum measurement of the main bench is at a country bank 2 miles southeast of Kammerer (Pl. VI, section 23). The roof is generally sandstone, but here and there shale, and in one instance the coal is separated from the sandstone by a foot of fire clay.

The lower of the two partings occurs from 2 inches to 2 feet above the bottom of the seam and in extreme cases measures a foot. The fact that the lower bench has not always been recorded is doubtless because it is usually thin and the operators do not think it worth while to take it out. The mine tracks are laid on top of the clay above it.

A rather peculiar condition exists south of Vanceville, where the coal is locally split into two divisions several feet apart, separated by shale (sections 37 and 38). Both divisions are worked. The upper one is in turn split into two benches, separated by clay, probably corresponding with the usual "roof coal" and main bench. This opening shows the two benches 12 and 30 inches thick, separated by 13 inches of clay. This coal is very hard. The lower division measures 54 inches of coal, which is rather bony. In both divisions it contains a large percentage of sulphur. This is the only locality where the Waynesburg coal is certainly known to be split, but that such instances are probably numerous is indicated by the occurrence at several points in the quadrangle of two distinct blossoms separated by a few feet of shale or débris.

At a country bank on North Branch of Pigeon Creek the Waynesburg bed is said to consist of 8 feet of solid coal; but this statement can not be corroborated, as the entry has now fallen in. In the vicinity of Kammerer the coal has been mined at several country banks. At the Kammerer opening the two upper benches measure in all 38 inches, including 2 inches of shale, corresponding to the fire-clay parting found elsewhere (section 22).

This coal has been opened at many banks in the vicinity of Deemston and Zollarsville and a number of sections have been measured (sections 43 to 51), detailed sections of which follow:

Detailed measurements of the Waynesburg coal in the vicinity of Deemston and Zollarsville.

No. of section on Pl. VI.	Location.	Fire-clay.	Coal.	Fire-clay.	Coal.	Fire-clay.	Coal.	Total.
		Ft. in.	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*
43	1 mile north of Deemston		1	11½	2	1	9	4 9½
44	do	(a)	9	1 2	b 3	3	4	5 6
45	1.2 miles west-northwest of Deemston	(a)	3 2					3 2
46	1.3 miles northeast of Deemston		10	6	2 8	4	8+	5
47	1 mile north-northeast of Zollarsville	a 6	1 1	1	2 5			5
48	"Horn's bank," Zollarsville		1 c 10	7	1 4	(d)	1 3	5
49	do		2	3 6	2 10			6 6
50	0.3 mile southwest of Zollarsville	a 1 6	1 1	10	2+			5 5+
51	"Just above Zollarsville" e		1 1	1	2 10			4 11

a Sandstone rock.
b Contains 2 inches of bone 10 inches from bottom of the bench.
c Contains thin clay partings.
d Very thin.
e Second Geol. Survey Pa.. Rept. K, p. 181.

These vary in thickness from 3 to 5½ feet, and in general show a fair correspondence, though the agreement is not so close as in the Pigeon Creek district. All the sections contain a main bench of 24 to 38 inches and with one exception have above the main fire-clay parting a roof coal reaching a maximum thickness of 22 inches, but averaging about 10 inches. In one case the sandstone roof rests directly on the main bench (section 45). The bottom coal is separated from the main bench by 1 to 4 inches of fire clay. In three cases the main bench is divided by a knife edge to 2 inches of bone or shale (sections 40, 44, and 48). As a rule the roof is sandstone, but locally it is shale and in some places fire clay. In the last case the clay is only 6 to 18 inches thick, and directly above it the sandstone is present, as usual. The main fire-clay parting thickens up here and there, as shown in Horn's bank (section 49), to 3 or 4 feet. In this section the "roof coal" is bony. The other section of Horn's bank (section 48) is more nearly the average.

On Little Tenmile Creek at the village of Lone Pine the Amity anticline brings the coal above stream level for about a mile, and it is worked at a number of country banks. The sections measured here show great uniformity (sections 52 to 58), and may therefore be taken as average for the Waynesburg coal in this region. Details are given in the next table.

Detailed measurements of the Waynesburg coal in the vicinity of Lone Pine.

No. of section on Pl. VI.	Location.	Fire clay.	Coal.	Fire clay.	Coal.	Fire clay.	Coal.	Total.
		Ft. in.	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*
52	0.3 mile southeast of Lone Pine		1	11	2 8	5	8	5 8
53	"McCrerey bank," Lone Pine		10	1 1	[a] 2 8	7	6	5 8
54	Lone Pine		1	1 2	2 7	4	6	5 7
55	.....do. [b]		1	1	3 3	3	6	6
56	.....do. [b]		6	1 2	2 10	6	6	5 6
57	On Brush Run, Lone Pine [c]		1 3	1	3 1	3	10	6 5
58	On Little Tenmile Creek, above Lone Pine [c]		1 2	10	3 8	2	6	6 4

[a] Contains a thin binder.
[b] Second Geol. Survey Pa., Rept. K, p. 186.
[c] Op. cit., p. 183.

At Lone Pine the bed consists of roof coal 10 to 15 inches, white fire clay 11 to 14 inches, main coal 31 to 44 inches, fire clay 2 to 7 inches, and bottom coal 6 to 10 inches, the total thickness being 65 to 77 inches. In one instance (section 53) the main bench contains a thin binder about the middle. The top bench of the coal is poor and is not mined, being left in to help hold up the roof, which is here generally shale. Locally, however, the sandstone rests directly upon the coal.

QUALITY.

In quality the Waynesburg coal is greatly inferior to the Pittsburg seam. It is a hard block coal with no coking value, and usually contains a high percentage of ash and sulphur. The ash averages 10 to 20 per cent and the sulphur 2 to 5 per cent. The coal is used principally by the farmers in the vicinity and is considered a very fair fuel in sections where no better coal is obtainable, as, for instance, in southern Washington and western Greene counties. The upper bench is generally of poor quality, and when the roof consists of shale is sometimes left in by the miners.

In the survey of the Amity quadrangle two samples of this coal were taken from Horn's bank, Zollarsville. They are of the roof coal and the main bench, respectively. These samples were taken according to the standard practice, as explained in connection with the Pittsburg coal (p. 95), and were analyzed at the fuel-testing plant at St. Louis. Two sets of analyses are given, the second of each being for coal "air-dried."

Analyses of Waynesburg coal from Zollarsville.

[E. E. Somermeier, analyst.]

	Roof coal.		Main bench.	
	As received.	Air-dried.	As received.	Air-dried.
Moisture	2.90	1.22	2.27	0.98
Volatile matter	31.68	32.23	32.39	32.82
Fixed carbon	45.76	46.55	47.13	47.75
Ash	19.66	20.00	18.21	18.45
	100.00	100.00	100.00	100.00
Sulphur	4.43	4.51	2.89	2.93

In the report on Washington and Greene counties Stevenson[a] gives a number of analyses, two of which are from localities in this quadrangle. They are as follows:

Analyses of Waynesburg coal from Washington County.

[D. McCreath, analyst.]

	1.	2.
Moisture	0.740	1.190
Volatile matter	36.040	36.585
Fixed carbon	46.890	43.489
Ash	13.955	15.930
Sulphur	2.375	2.806
	100.000	100.000
Coke	63.220	63.225

1. Rogers's bank near Beallsville. 2. J. Moniger's bank, Lone Pine.

WAYNESBURG "A" COAL.

The Waynesburg "A" coal is very persistent throughout the county and can usually be recognized by blossoms occurring 50 to 80 feet above the Waynesburg coal. It occurs above the Waynesburg sandstone and is in many places associated with thin limestones. Usually the coal is thin, but in a few localities its blossom is so conspicuous that it has been mistaken for the Waynesburg. This is especially true in sections where the Waynesburg sandstone is absent, and in such cases there is no sure guide to the coals.

Only two measurements of this coal are known. They amount to 20 and 27 inches (fig. 6, Nos. 19 and 20, p. 102), and the coal is much broken up by bone and clay. At one of these localities, 1½ miles southeast of Lone Pine, the coal has been opened. This is the only known open bank on this bed in the quadrangle. If this exposure represents the best of the coal, it will be readily understood that the Waynesburg "A" seam can never be of much value.

[a] Second Geol. Survey Pennsylvania, Rept. K, 1876, p. 278.

In Somerset Township, on North Branch of Pigeon Creek, the coal outcrops with the following section:

Section of Waynesburg "A" coal in Somerset Township.

	Ft.	in.
Sandstone	10	
Coal		10
Clay		4
Coal, slaty		5
Clay		2
Coal and shale	1	4

The Second Survey states that the Waynesburg "A" was once opened in West Bethlehem Township 1¼ miles northwest of Scenery Hill, but the thickness was only 15 inches.

WAYNESBURG "B" AND LITTLE WASHINGTON COALS.

These names have been applied at various times to thin coals occurring between the Waynesburg "A" and Washington beds in various parts of Greene and Washington counties. It is true that blossoms have frequently been found in this interval, and in one or two instances thicknesses as great as 1 to 2 feet have been reported, but it can be safely said that neither of the beds is of any value.

WASHINGTON COAL.

The Washington coal is known from the locality of its typical occurrence. It is 110 to 160 feet above the Waynesburg coal and directly below the Lower Washington limestone. This coal is much more persistent than any other coal bed of the Dunkard group, and reaches in many places a thickness of several feet, although on account of its numerous shale partings it is of little commercial value. At no point in the Amity quadrangle is the bed now worked, but conspicuous blossoms usually occur wherever its horizon crosses a road.

THICKNESS.

In the vicinity of Washington the coal is exposed at a number of points and locally reaches a thickness of 7 feet. It usually consists of many divisions of coal and shale. One of the best exposures to be seen is that in the Baltimore and Ohio Railroad cut just off the quadrangle in the western part of Washington. The coal is here 7 feet 1 inch thick and is overlain at a few feet by the Lower Washington limestone. The coal is subdivided by bands of clay, as shown in fig. 6, No. 14, page 102; the section follows:

Coal section in Baltimore and Ohio Railroad cut west of Washington (fig. 6, No. 14).

[Second Geol. Survey, Pennsylvania, Rept. K, p. 52.]

	Ft.	in.
Coal		3
Fire clay		8
Bituminous shale		10
Fire clay	1	3
Coal		5
Fire clay		1
Coal		2
Fire clay		2
Coal		3
Fire clay		3
Coal	2	9
	7	1

It is reported that along Little Chartiers Creek, on the boundary between South Strabane and Somerset townships, the Washington coal was once opened and had a thickness of 2 feet 6 inches. In numerous places on the ridge separating North Strabane and Nottingham townships it amounts to several feet. Stevenson reports a thickness of 2 feet 7 inches on Tenmile Creek[a] in Amwell Township, but it is here separated into three benches by two thick fire-clay partings (fig. 6, No. 15). In West Bethlehem Township, 1½ miles above Zollarsville,[b] it measures in all 3 feet 3 inches, but 11 inches of this is clay (fig. 6, No. 16). At Tenmile village 3 feet 6 inches is reported, containing two fire-clay partings, 5 and 6 inches in thickness (see fig. 6, No. 17).

In the vicinity of Dunn station and West Amity the coal is recorded in a number of wells. On Little Daniels Run, 2 miles southwest of Scenery Hill, it was once opened and is reported 20 inches thick.

QUALITY.

Usually where the Washington coal has been seen in the quadrangle, it is made up of many alternating layers of coal and shale and is in general a very inferior coal. In neighboring districts, however, it is frequently found of fair quality, sometimes equaling the Waynesburg bed in value. No analyses have been made of the Washington coal in this quadrangle, but the following analyses from banks near Taylorstown, Washington County, and Ryerson Station, Greene County, are given to show the composition of the Washington coal when at its best:

[a] Second Geol. Survey Pennsylvania, Rept. K, 1876, p. 52.
[b] Op. cit., p. 181.

Analyses of Washington coal from western Greene and Washington counties.

	1.		2.
	As received.	Air dried.	
Moisture	2.22	1.73	1.695
Volatile matter	36.79	36.97	39.150
Fixed carbon	46.96	47.20	46.658
Ash	14.03	14.10	10.525
	100.00	100.00	100.00
Sulphur	3.79	3.81	1 972
Moisture loss on air drying		.50	
Coke			59.155
Color of ash			Gray.

1. Near Ryerson Station, western Greene County. Sample taken according to standard method (see p. 95); analyzed at fuel-testing plant, St. Louis, Mo., by E. E. Somermeier.

2. Near Taylorstown, Buffalo Township, Washington County; analyzed by A. S. McCreath (Second Geol. Survey Pennsylvania, Rept. K, 1876, p. 376).

These analyses show a coal comparing very favorably with the Waynesburg bed. Usually, however, the quality is inferior to this, in respect both to ash and sulphur.

JOLLYTOWN COAL.

The name Jollytown was used by Stevenson in 1876[a] for a coal 40 to 50 feet below the Upper Washington limestone, and by I. C. White[b] in 1891 for a coal and limestone above the Upper Washington limestone. In the Waynesburg folio (1905) R. W. Stone followed Stevenson's use of the word, and that usage is maintained, as Stevenson had the right of priority. In the Amity quadrangle this coal is not known except at a few points in Amwell and West Bethlehem townships, where it appears as a faint blossom 60 to 80 feet below the Upper Washington limestone. It has been reported up to 20 inches in thickness.

TENMILE COAL.

About 30 feet above the Upper Washington limestone there occurs in many places a thin coal bed which was erroneously called by I. C. White the Jollytown, but it is not equivalent to the Jollytown of Stevenson, which occurs below the Upper Washington limestone. The name Tenmile coal is here suggested for this bed. The coal has been noted at a number of localities throughout West Bethlehem and Amwell townships, but is best developed south of Tenmile Creek. At several points it has been opened and found to reach a thickness of 1 to 3 feet. About 2.2 miles west-southwest of Tenmile village a thickness of 38 inches was measured. The coal contains thin partings and occurs between a black shale and shaly sandstone.

[a] Second Geol. Survey Pennsylvania, Rept. K, 1876, p. 48.

[b] Bull. U. S. Geol. Survey No. 65, 1891, p. 34.

LOCAL COALS.

On Cemetery Hill, Washington, a coal 18 inches thick occurs 5 feet above the Upper Washington limestone and 5 feet below an 8-foot bed of limestone. Another coal blossom has been noted at several localities at an estimated interval of 170 to 200 feet above the Upper Washington limestone. This is probably equivalent to the Dunkard coal of southern Greene County.

COALS WHICH DO NOT OUTCROP.

COALS IN THE CONEMAUGH FORMATION.

Coal beds in the Conemaugh formation are usually thin and irregular in occurrence, but several horizons are known at which they appear to be rather persistent. One of these is reported in several wells in Washington County. In the Isaac Horn No. 1 well (283), near Zollarsville, it occurs at an interval of 445 feet, in the Joseph B. Wise No. 1 (303) at 410 feet, and in the Luse well (15) at 384 feet below the Pittsburg coal. The average interval to the Upper Freeport coal in this vicinity being assumed as 600 feet, the intermediate coal in these wells occurs at about 155, 190, and 216 feet, respectively, above the Upper Freeport. These intervals agree well with that of the Bakerstown coal, a thin bed which is present in many places in Allegheny and Beaver counties. In the Horn No. 2 well another coal has been noted 245 feet below the Pittsburg bed.

COALS IN THE ALLEGHENY FORMATION.

Except in one or two instances only two coal beds of this formation are recorded in wells of the Amity quadrangle. These beds are the Upper Freeport ("Connellsville") and a bed which lies about 150 feet below it.

The Upper Freeport coal lies at the top of the Allegheny formation and seems to be very persistent. The quality of this coal is not known, but the bed is reported in a number of deep wells. Its depth below the Pittsburg coal is given in the following table:

Distance from top of Pittsburg coal to top of Upper Freeport coal, as shown by drill records.

No. on Pl. I.	Name of well.	Location.	Distance.	Thickness of Upper Freeport coal.
			Feet.	*Feet.*
	C. M. Reed	South Strabane Township	600	
29	Matilda Davis No. 2	Borough of Deemston	604	10
24	A. B. Crumrine	do	604	4
37	Oberholt	do	600	7
28	Wm. Crumrine	do	580	11
45	J. L. Thompson No. 2	do	564	5
46	J. L. Thompson No. 3	do	600	5

Distance from top of Pittsburg coal to top of Upper Freeport coal, etc.—Continued.

No. on Pl. I.	Name of well.	Location.	Distance.	Thickness of Upper Freeport coal.
			Feet.	*Feet.*
47	J. L. Thompson No. 4	Borough of Deemston	597	5
48	J. L. Thompson No. 5	do	610	10
43	Hiram Teagarten	do	575	5
49	Wm. Ward	do	582	6
265	Reed	Borough of Washington	595	
281	Uriah Hill heirs	West Bethlehem Township	596	6
299	Thompson & Seaman Coal Co	do	587	
307	Peter Nickerson	West Pike Run Township	607	3
308	S. F. Scott	do	574	
	Average		585	

The lower coal is reported only in the Elizabeth Morton No. 1 (291), Winnet McCarthy No. 2 (289), and Frank McCarthy No. 1 (286) wells in West Bethlehem Township. Its distance below the Pittsburg bed is 755, 745, and 750 feet, respectively. In those wells the coal is reported as the "Connellsville," but since the distance from the Pittsburg is too great, it is believed to be more probably the equivalent of one of the Kittanning group. What may be the same coal is recorded in the A. M. Wickerham well (50) in the borough of Deemston, but in this case the distance is only 721 feet. In the Luse well (15) near Beallsville, and in the Gantz well at Washington, a coal is recorded 672 feet and 653 feet, respectively, below the Pittsburg. This may possibly be the Lower Freeport coal of the Allegheny Valley, which in the vicinity of Connellsville is locally present about 40 feet below the Upper Freeport.

The A. C. Mitchell well, in West Pike Run Township, is the only one in the quadrangle which shows three coal beds in the Allegheny formation. In this record the following section is given:

Section of Allegheny formation in the A. C. Mitchell well, West Pike Run Township.

	Feet.
Coal (Upper Freeport)	*5*
Lime	29
Sand	10
Slate	24
Sand	32
Slate	14
Coal (Upper Kittanning?)	*5*
Slate	37
Coal (Middle Kittanning?)	*8*
Lime	20
Slate	25
Sand	45
Black lime	10
Slate	18
Sand	30
Slate	12
	324

LIMESTONE.

RELATIVE ABUNDANCE.

The rocks of the Monongahela and Washington formations present a striking contrast to the underlying Carboniferous rocks in the proportion of limestone they contain. While in the Pottsville, Allegheny, and Conemaugh formations beds of limestone are rare and, with a few exceptions, very thin, in the Monongahela and Washington deposits they are frequently found up to 20 or 30 feet in thickness, and in the Monongahela they make up nearly one-half the thickness of the formation. This is illustrated by a diamond-drill hole near Bissell, which reports between the Waynesburg and Pittsburg coals 130 feet of limestone, being over 41 per cent of the total thickness of the beds. This is due largely to the great thickness of the Benwood limestone. In the Washington formation the amount of limestone is less, but at least three beds reach thicknesses of 20 to 30 feet.

USES.

Certain impure limestones containing large percentages of silica, alumina, and iron oxide are capable of forming cement when burned in a kiln at a comparatively low temperature. Cements made in this manner are known as natural cements and are of much poorer quality than Portland cement, which is generally made from the purer limestones. For natural cement a limestone containing as high as 15 to 40 per cent of impurities is necessary. This kind of cement has been made in the past in southwestern Pennsylvania to a limited extent, principally for use in the construction of locks on Monongahela River. The bed used for that purpose was a part of the Benwood limestone.

Portland cement,[a] which has for years surpassed all other kinds of cement in its value and use, requires a purer limestone. The proportion of magnesium carbonate ($MgCO_3$), especially, must be low—preferably less than 3 per cent. In general the amount of calcium carbonate ($CaCO_3$) must be at least 75 per cent, and the remainder (20 per cent) includes silica (SO_2), alumina (Al_2O_3), and iron oxide (Fe_2O_3).

The principal use of limestones in this region at the present time is for road material, several quarries for this purpose being situated in the vicinity of Washington. The limestones seem also to be suited for railroad ballast, and when nearly pure carbonate of lime they may be used for flux in iron smelting. One of the most widespread uses of limestone in Pennsylvania has been for fertilizer, and for this purpose almost any except the most impure limes are suited. In Washington County, however, the great abundance of limestone beds

[a] A detailed discussion of the Portland cement industry and cement-making limestones of the United States is given by E. C. Eckel in Bull. U. S. Geol. Survey No. 243, 1905.

has naturally formed a very good soil, and, as a rule, no burned lime is necessary on the land. In a few instances only were evidences that lime had been burned seen in the fields.

The principal limestone beds in the area are described from the bottom upward.

LIMESTONES BETWEEN THE PITTSBURG AND WAYNESBURG COALS (MONONGAHELA FORMATION).

FISHPOT LIMESTONE.

The Fishpot limestone underlies the Sewickley coal at a distance of a few feet. It was originally named by Stevenson from Fishpot Run, in the southeast corner of Washington County, but I. C. White[a] has applied the term Sewickley to this same limestone. During the present survey this bed was observed underneath the coal on Fishpot Run, where 30 feet of it is reported, and on Mingo Creek. In sinking the Enterprise mine shaft, 1 mile north of Washington, according to report 30 feet of limestone was found directly below the coal. Thin sandstone beds also frequently occur in this interval.

A sample of this limestone from Fayette County was analyzed by the Second Geological Survey[b] and found to have the following composition:

Analysis of Fishpot Limestone from Fayette County.

Insoluble residue	10.770	Sulphur trioxide (SO_3)	0.052
Calcium carbonate ($CaCO_3$)	80.647	Phosphoric oxide (P_2O_5)	.066
Magnesium carbonate ($MgCO_3$)	2.217	Water	1.010
Ferrous carbonate ($FeCO_3$)	1.657	Carbonaceous matter	1.250
Iron disulphide (FeS_2)	1.125		
Alumina (Al_2O_3)	.543		99.337

Compact; minutely crystalline; spotted with pyrite; dark blue.

If the bed attains this composition in Washington County, it should be of some value in the manufacture of Portland cement. One analysis, however, is not sufficient to justify a positive statement of this kind, since another analysis shows too large a proportion of magnesia.

BENWOOD LIMESTONE.

The Benwood (or Great) limestone is by far the most important limestone in the quadrangle. The name was suggested by I. C. White from the town of Benwood, near Wheeling, W. Va. In places it reaches, with its interbedded shales, a thickness of 160 feet, the proportion of limestone being usually about three-fourths of the whole. The detailed section of the Benwood varies somewhat, but it consists

[a] Bull. U. S. Geol. Survey No. 65, 1891, p. 62.
[b] Rept. MM, 1879, p. 287.

uniformly of a double composite bed; that is, it contains a lower and an upper member separated by a considerable thickness of shale, both members being in turn divided into a number of layers separated by thin beds of shale.

At several points in the Amity quadrangle the Benwood is well exposed. In several ravines northeast of Kammerer, in eastern Nottingham Township, and in Union Township, off the edge of the quadrangle, the exposures are especially good. At one point, on a small run on the boundary of the quadrangle, in Union Township, the stream makes a perpendicular fall of 30 feet, caused by resistance to erosion of one of the limestone strata and the consequent undercutting of 25 feet of soft interstratified shales (Pl. VII, *A*). Similar falls, of less height, occur on several of the small streams in this vicinity. One of the best measured sections of this limestone is at the mouth of Brush Run, Peters Township, in the Carnegie quadrangle, as follows:

Section of Benwood limestone at mouth of Brush Run, Peters Township.[a]

	Ft.	in.
Concealed	117	
Limestone	1	
Sandstone	5	
Limestone, brecciated	2	6
Concealed	15	
Limestone	4	6
Sandstone	14	
Concealed	15	
Shale	5	
Limestone	12	
Shale	12	
Limestone	50	
Shale, sandy, to creek	15	

A fair section of this limestone is also given in the record of the Moses Smith diamond-drill hole, near Bissell (p. 16). Several oil and gas wells report the limestone, but such records are less reliable than surface measurements.

In general, the Benwood limestone is considerably broken up by shale, as in the section just given, but a hard layer 30 to 50 feet thick near the bottom seems to be very persistent. The character of the limestone is variable. The "Uniontown" member, or upper portion, contains in many places 6 to 15 feet of an impure brownish to buff-colored limestone. The lower portion is generally a hard, pure limestone of light-brown to gray colors. One thin stratum weathers very yellow, with a peculiar honeycombed appearance. The rock is in many places siliceous or argillaceous and in some ferruginous. The bottom portion is said to be generally the more magnesian, although all portions are high in magnesia, as indicated by the first three of the

[a] Stevenson, J. J., Second Geol. Survey Pennsylvania, Rept. K, 1876, p. 226.

A. WATERFALL OVER BENWOOD LIMESTONE, UNION TOWNSHIP.

B. OUTCROP OF LOWER WASHINGTON LIMESTONE ON SMITH RUN, AMWELL TOWNSHIP.

following analyses. In Washington County the limestone was considerably used in early days in the manufacture of natural cement, but is nowhere suitable for Portland cement, on account of the large proportion of magnesia.

Analyses of Benwood limestone from Washington County.

	1.	2.	3.	4.
Insoluble residue	13.300	22.520	15.750	14.920
Calcium carbonate ($CaCO_3$)	68.837	48.823	47.080	47.750
Magnesium carbonate ($MgCO_3$)	14.649	20.621	28.528	30.943
Ferrous carbonate ($FeCO_3$)	3.306	3.625	7.511	5.608
Alumina (Al_2O_3)		3.523		
Sulphur	.097	.203	.069	.126
Phosphorus	.049	.051	.127	.015
	100.238	99.366	99.065	99.362

1. One mile north of Canonsburg; upper layer, very hard and compact, like conglomerate, bluish gray Second Geol. Survey Pennsylvania, Rept. K, 1876, p. 388; analysis by A. S. McCreath.

2. One mile north of Canonsburg; middle layer, compact, somewhat shaly bluish gray. Loc. cit.; analysis by D. McCreath.

3. One mile north of Canonsburg; lower layer, hard, compact, unctuous, pearl gray. Loc. cit.; analysis by D. McCreath.

4. Property of Doctor Shaner, in Somerset Township, 8 miles from Washington. Second Geol. Survey Pennsylvania. Rept. MM, 1879, p. 285; analysis by D. McCreath.

WAYNESBURG LIMESTONE.

The Waynesburg limestone is a bed 4 to 20 feet in thickness, occurring below and within 40 feet of the Waynesburg coal. It is exposed and readily accessible at a number of places in various parts of the quadrangle. It is usually of a dark-gray color and makes a strong, but rather dark lime. The utility of this limestone has not been tested.

LIMESTONES ABOVE THE WAYNESBURG COAL (IN THE DUNKARD GROUP.

Scattered throughout the Dunkard group are abundant limestone beds, which were described by the Second Geological Survey and given numbers from I to XIV, inclusive.[a] Several of these beds are known to be persistent over considerable areas and can be recognized as distinct beds. Most of them, however, in the upper portion of the Dunkard have been shown by recent field work in western Greene County to be local in their occurrence and many of them can not be correlated with any bed at a distance. The more important beds are described in the following paragraphs.

LOCAL LIMESTONES BETWEEN THE WAYNESBURG AND WASHINGTON COALS.

Below the Waynesburg "A" coal and above the Waynesburg sandstone there occurs locally a limestone which was noted by Stev-

[a] White, I. C., Bull. U. S. Geol. Survey No. 65, 1891, p. 39.

enson, but not named. It is well exposed on Dunkard Creek, at Mount Morris, Greene County, and has therefore been designated by I. C. White[a] the "Mount Morris limestone." In places in Washington County it is 5 to 10 feet thick, but is not persistent. It can be seen at many points in the eastern half of the quadrangle. It is commonly blue gray in color and weathers yellowish.

A limestone is often found above the Waynesburg "A" coal also. It reaches a thickness of 8 to 10 feet and has generally a buff color. By I. C. White[a] it was named the "Colvins Run limestone," from Colvins Run, in Greene County.

LIMESTONES ABOVE THE WASHINGTON COAL.

LOWER WASHINGTON LIMESTONE.

This is the lowest of the three principal limestones occurring near Washington and named after that town. It forms the roof of the Washington coal. Here and there, however, a few feet of shale intervenes between the coal and the limestone. The Lower Washington occurs from 150 to 220 feet below the top of the Upper Washington limestone and 120 to 150 feet above the Waynesburg coal. Washington County is the region of its best development, and here its thickness ranges up to 30 feet. It is generally interstratified with much shale, as shown in the following section:

Section of Lower Washington limestone and associated shale on Smith Run.

	Ft.	in.
Limestone	9	6
Shale, black		5
Limestone		7
Shale, black		4
Limestone		1
Shale, black and soft		2
Limestone		2
Shale, black		2
Limestone, hard, blue to black, weathers white		9
Shale, soft, black	2	
Fire-clay shale, dark		4
Coal, bony		2
Shale, black		4
Fire-clay shale, dark		5
	15	5

An illustration of the outcrop of the above section is given in Pl. VII, *B*.

One mile southeast of Hackneys station, near Tenmile Creek, the following section was measured:

[a] White, I. C., Bull. U. S. Geol. Survey No. 65, 1891, p. 39.

Section of Lower Washington limestone near Hackneys.

	Ft.	in.
Limestone	1	
Shale, bituminous	2	
Limestone	1	
Clay		4
Limestone	1	
Clay		8
Limestone		6
Clay	1	
Limestone	1	
Clay		6
Limestone		2
Clay		6
	9	8
Coal, Washington	1+	

Still another good section occurs near Zollarsville. The measurement is as follows:

Section of Lower Washington limestone 2 miles west-northwest of Zollarsville.

	Ft.	in.
Limestone	2	
Shale, bituminous		3
Limestone		3
Shale, bituminous		2
Limestone		3
Shale, bituminous		1
Limestone		7
Shale		½
Limestone		3
Shale, bituminous		3
Limestone	1	
Shale, bituminous	2	
Limestone		6
Shale, bituminous	2	
Limestone	1	
	10	7½

The Lower Washington limestone is usually a hard, compact limestone, having a light blue-gray to fleshy color and commonly weathering bluish white. The color is not distinctive, and in general it can be said that in none of the limestones in the Dunkard formation is the color a certain guide to the identity of the bed. The colors mentioned are characteristic, however, and usually assist in identification. The utility of this limestone has not been tested, but at many widely scattered points it is rather massive and would seem to be of possible future value.

MIDDLE WASHINGTON LIMESTONE.

The Middle Washington limestone occurs 60 to 100 feet above the Lower Washington and 100 to 140 feet below the Upper Washington

limestone. Where exposed it is a hard, compact light-grayish or flesh-colored rock, usually coarsely brecciated and containing numerous spots of crystalline calcite, many of them replacing fossil shells. The limestone can generally be recognized by the great quantity of iron it contains, giving it a weathered surface of bright yellow, which in many exposures extends to a depth of several inches and finally exfoliates and crumbles off. Some of the basal layers are more earthy and slaty and do not have this characteristic. The bed is locally 10 to 20 feet thick, but usually much thinner.

The Middle Washington limestone has a wide distribution in the quadrangle, but its typical occurrence is near Washington. In a cut of the Baltimore and Ohio Railroad in the eastern part of the town the large yellow bowlders from the bed are finely exposed. This limestone has never been used and does not appear to be of value.

JOLLYTOWN LIMESTONE.

In accordance with the usage of Stevenson (1876), this term is applied to the limestone occurring above the Jollytown coal and 30 to 40 feet below the Upper Washington. It is a hard, grayish, locally brecciated limestone, weathering light gray to dirty yellow. Owing to its peculiar character it is a good key rock. It is in places several feet thick, and appears below the Upper Washington limestone on most of the roads in the southwestern part of the quadrangle and in a few places elsewhere.

UPPER WASHINGTON LIMESTONE.

The Upper Washington limestone is the topmost bed of the Washington formation and, with the exception of the Waynesburg sandstone, is the most conspicuous and persistent member of the Dunkard group. For this reason it was chosen as the best horizon at which to subdivide the group into formations. It occurs 630 to 710 feet above the Pittsburg coal and 280 to 400 feet above the Waynesburg coal. The outcrop of this limestone throughout the quadrangle is represented on the geologic map (Pl. I, pocket) by the heavy green line separating the Washington and Greene formations.

The characteristics of the Upper Washington limestone are rather distinctive. It is hard, compact, and brittle, and is generally made up of a number of layers separated by thin beds of shale. Throughout the greater part of Washington County its upper part on fresh fracture has a dark blue-gray, bluish black, or even nearly black color. Generally it contains drab and mottled layers. The rock as a rule is very pure. In some portions of the district it is easily recognized by its weathered surface, which is almost snowy-white, with a slight tinge of blue. It varies in thickness from 4 to 30 feet.

The best exposures of this limestone are to be seen in the vicinity

of Washington, where it reaches a thickness of nearly 30 feet. The tunnel of the Baltimore and Ohio Railroad, 1 mile east of town, cuts through the bed, exposing at its west end the section given below. The limestone is quarried at this place.

Section of Upper Washington limestone 1 mile east of Washington.

	Ft.	in.
Limestone, blue-black	2	3
Shale, black		2
Limestone, blue-black		10
Shale		4
Limestone, blue-black, brittle	1	10
Shale, black	2	2
Limestone, hard, gray, and thin shale	5	4
Shale, soft, dark		6
Limestone, light brownish gray, very hard, to level of railroad	3	6
	16	11

On Cemetery Hill, in the southwestern part of Washington, just off the quadrangle, a section of 19 feet exposed in an old quarry is made up of a great many thin beds of alternating limestone and shale. The detailed measurement of an average section here is as follows:

Section of Upper Washington limestone on Cemetery Hill, Washington.

	Ft.	in.
Limestone, gray-brown	1	
Shale, soft, black	1	
Limestone, hard, blue-black	2	5
Shale, black		4
Limestone, brown-gray		11
Shale, soft, black		2
Limestone, blue-black	1	8
Shale, black	1	1
Limestone, compact, brown-gray	3	
Shale, yellow		1
Shale, hard, black, slaty		2
Limestone, brown		10
Shale, light brown		2
Limestone, hard, brown	2	2
Shale, soft, dark		4
Limestone, hard, brown		4
Shale		3
Limestone, hard, brown	1	8
Fire-clay shale, dark	1	
Limestone, brown-gray; bottom of quarry.		
	18	9

The total thickness of the limestone on Cemetery Hill is 30 feet, as shown in the following section taken from Stevenson:[a]

Section of Upper Washington limestone at Washington.

	Ft.	in.
Limestone, laminated, argillaceous	2	
Shale, dark	5	
Shale, calcareous	6	
Shale with vegetable markings	2	
Limestone		10
Shale, bituminous		10
Limestone	2	
Shale, calcareous	1	3
Limestone	1	6
Shale		10
Limestone	3	
Shale	2	
Limestone	3	
	30	3

Another good section of a part of the limestone is exposed in a quarry one-half mile northeast of Washington, on the Williamsport pike. It is here quarried and crushed for road metal. The limestone is well exposed on all the roads leading out of Washington to the east and south, and outcrops at many points in the Nineveh syncline in South Strabane, northern Amwell, and South Franklin townships. In this region great care is necessary to avoid confusing it with another limestone which occurs 100 to 130 feet above. This limestone is also dark blue to black in color, and in thickness and other characteristics seems to be almost the exact counterpart of the Upper Washington.

A good exposure of the Upper Washington limestone appears in a quarry on the hill just southeast of Washington. The bed is here 15 feet thick. On the uplands in the vicinity of Mount Wheeler the limestone is deeply buried, but it appears again for about a mile between Vankirk station and the Chambers dam, and south of McCracken station is exposed along Bane Creek from 100 to 200 feet above the floor of the valley. In the vicinity of Amity and in general throughout the southern portion of Amwell Township it is high up on the hills, brought up by the Amity anticline. South of Tenmile Creek it is overlain by 200 to 400 feet of rock and its outcrop follows the valleys and ravines for the entire distance between Dunn station and Bissell.

Throughout West Bethlehem Township outcrops of the limestone are numerous, but they all occur high up on the hills, so that they appear on the map as mere patches. In the vicinity of Scenery Hill

[a] Second Geol. Survey Pennsylvania, Rept. K, 1876, p. 46.

the outcrops are a little more extensive. One of the most continuous exposures of the limestone in the quadrangle is on the long ridge on which the road runs, extending in a northeast-southwest direction, about midway between Daniels and Plum runs west of Beallsville. The limestone seems to be at least 30 feet thick and appears for several miles near the top of the ridge as numerous dark blue-gray fragments. It has been quarried on a knob about a mile west of Beallsville and also on the National pike, one-half mile northeast of Odell, where it shows the following section:

Partial section of Upper Washington limestone near Odell.

	Ft.	in.
Shale (4 + feet).		
Limestone, dark blue-gray	1	8
Shale, dark		10
Limestone, dark blue-gray		11
Shale, black	1	1
Limestone, light gray	2	3
	6	9

On a hill near by the thickness of the limestone appears to be as great as 50 feet.

Near the middle of the Upper Washington limestone occurs a dark layer which contains great numbers of little fossils. The rock from this layer gives a peculiar fetid odor when struck by the hammer.

The Upper Washington limestone is, as a rule, a fairly pure bed. A sample of it taken from the railroad tunnel east of Washington, was analyzed by the Second Geological Survey[a] and shown to have the following composition:

Analysis of Upper Washington limestone near Washington.

[D. McCreath, analyst.]

Insoluble residue	17.380	Sulphur	0.155
Calcium carbonate ($CaCO_3$)	72.866	Phosphorus	.061
Magnesium carbonate ($MgCO_3$)	3.813		97.204
Ferric oxide (Fe_2O_3)	2.929		

This limestone is quarried at several points in the area. At present the most important output is from a quarry at the west end of the railroad tunnel east of Washington, the rock being used for railroad ballast. One mile northeast of Washington, on the Williamsport pike, is a small quarry operated by the Hallam Construction Company. The rock is crushed and used in macadamizing the streets of the town. The principal use of the limestone thus far has been for road metal and railroad ballast. If the proportion of calcium carbonate, as shown in the analysis, holds throughout the quadrangle, this bed would seem to be a possible source of lime for the manufacture of cement. The stone has been burned in many places for a fertilizer.

[a] Rept. MM, 1879, p. 388.

PROSPERITY LIMESTONE.

The Prosperity limestone is a bed not mentioned in the old Pennsylvania reports, and it was probably confused with the Upper Washington bed, to which it is very similar in appearance. The name "Prosperity" has been suggested by Mr. M. J. Munn from the village of that name in Washington County. The horizon of this bed is 100 to 180 feet above that of the Upper Washington, and the limestone outcrops at many points in South Strabane and Amwell townships as a hard, dark blue-gray to nearly black rock.

In thickness the Prosperity limestone is supposed to reach in places 20 feet. So far as known, it has not been tested, but from its compact nature and considerable thicknesss it would seem to be of probable future value, although in this quadrangle it is not very accessible.

SANDSTONE.

The sandstones of the Amity quadrangle are in general shaly and of poor quality, but a number of beds seem to offer stone of possible value.

PITTSBURG SANDSTONE.

This name is applied to a bed of sandstone ranging up to 70 feet in thickness, which in many places overlies the Pittsburg coal. Where best developed it is coarse and friable. It can be seen at several points on Chartiers and Peters creeks, but is there poorly developed. On Fishpot Run, on the edge of the quadrangle near its southeast corner, the sandstone is well exposed in cliffs which rise above the Pittsburg coal to a height of nearly 100 feet (Pl. VIII *A*). So far as known, the Pittsburg sandstone has not been utilized.

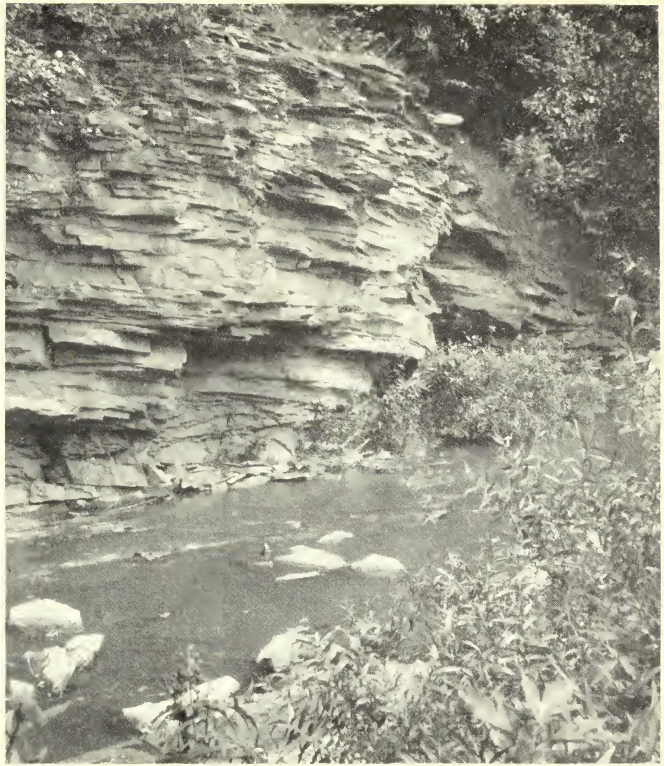
WAYNESBURG SANDSTONE.

The Waynesburg is a coarse, flaggy, much cross-bedded sandstone, from 20 to 70 feet thick, resting on the Waynesburg coal or separated from it by a few feet of shale. Its color is usually buff-yellow to light gray. The name is derived from the town of Waynesburg, near which the rock is finely exposed. This is one of the most conspicuous and persistent sandstones in the upper portion of the Carboniferous system, and furnishes a good guide to the position of the Waynesburg coal.

In the Amity quadrangle the Waynesburg sandstone is probably most prominent on Little Tenmile Creek, in the vicinity of Lone Pine, where it crops out in 30-foot cliffs directly above the Waynesburg coal. At this locality it forms a flat terrace on which part of the village has been built, about 40 feet above the creek. The terrace and the character of the sandstone are illustrated in Pl. VIII, *B*.

The sandstone is also finely exposed on Little Chartiers Creek between the National pike and Linden, where it can be traced along

A. OUTCROP OF PITTSBURG COAL AT BASE OF PITTSBURG SANDSTONE IN VALLEY OF FISHPOT RUN, EAST BETHLEHEM TOWNSHIP.



B. BLUFF OF WAYNESBURG SANDSTONE AT LONE PINE, ON LITTLE TENMILE CREEK.

the public road for several miles, also in the neighborhood of Zollarsville, on Pike Run, throughout the borough of Deemston, and on South Branch of Pigeon Creek. On North Branch of Pigeon Creek, Mingo Creek, and farther north the sandstone is of little importance, being usually either shaly or replaced by shale. In the vicinity of Washington and Houston and in general over the northwestern portion of the quadrangle the sandstone is poorly developed or missing. In general, it may be said to be well developed in Greene and southern Washington counties, but to die out toward the northern part of Washington County.

It is generally flaggy to shaly, but here and there rather massive. It is probably too friable to be of much value, but it is said to have been used in Greene County for building.

OTHER SANDSTONES

The only sandstone quarry of any account in the Amity quadrangle is between the National pike and the railroad tunnel a mile east of Washington, about 130 feet above the Upper Washington limestone outcropping at the entrance to the tunnel. A fair-sized quarry is operated here by the Hallam Construction Company, the stone being used for curbing and bridge construction and to a limited extent in buildings. The sandstone lies a few feet above a bed of limestone reported in a well and is a good, hard, massive rock. The same bed has been prospected in other parts of the quadrangle.

Other sandstone beds of variable character are distributed through the Dunkard group and some of them may prove to be of value.

CLAY AND SHALE.

Two classes of material suitable for making brick are found in this territory. These are clay and shale, the former being a surface deposit and the latter making up a large proportion of the hard rocks.

CLAY.

In this quadrangle there are both residual surface clays and deposits in the stream valleys. The residual clays are of low grade and are abundant. The stream deposits are not so widely distributed, but are available at several points. So far as known, they have not been used in the quadrangle, but just beyond the northern border, between Houston and Canonsburg, is a small brickyard operated by the Alexander Brick Company. The clay used here is a tough silty layer of buff color capping a gravel terrace of the Carmichaels formation. The material is somewhat gritty to the teeth, but contains no pebbles. Below this bed occurs from 6 inches to 3 feet of gravel, and underlying that 8 feet of hard clay is reported. The lower bed is not known to

have been utilized. The top clay is said to make very good brick, which are used for building in Canonsburg.

This clay occurs at several points in the quadrangle, but is of very local occurrence. It may be present on any of the rock benches in the valley of Tenmile Creek and elsewhere, but the patches are probably too local, thin, and gravelly to be of any importance in this area.

SHALE.

Shales of fine texture are very abundant in the Dunkard group and outcrop over wide areas. In other parts of the country some of these shales have been widely used in the manufacture of brick. In the Amity quadrangle and as a rule in western Pennsylvania they have been little used, but seem to offer a source of supply suitable for brick-making, and perhaps also in connection with limestone for making cement.

At only two points in the quadrangle is shale known to have been utilized. One of these is in the southern part of the borough of Washington, near the Baltimore and Ohio Railroad, where the Donley Brick Company operates a small plant for the manufacture of red brick. Shale is here worked in an open cut 25 feet deep, and it is said that an even greater thickness of the rock is suitable for the purpose. The shale is used just as it comes from the bank and is manufactured by the stiff-mud machine process, cut by automatic cutter. The company has been in operation for two years.

The Union Stone and Brick Company is operating at Vance station, on the Baltimore and Ohio Railroad. The pit from which the shale is obtained contains 15 to 20 feet of shale, above 40 feet of a micaceous sandy bed. For brick-making two parts of the lower bed and one part of the upper bed are used. The output in 1903 is reported to have been 1,500,000 brick.

WATER RESOURCES.

SURFACE DRAINAGE.

The Amity quadrangle contains no streams of large size. The most important are Tenmile Creek and its branches, Chartiers, Little Chartiers, Mingo, and Peters creeks, all of which rise within the limits of the quadrangle or near its borders. The largest stream is Tenmile Creek, which flows eastward nearly across the southern part of the quadrangle and has as branches on its north side Bane Creek, Little Tenmile Creek, and Daniels and Little Daniels runs. Chartiers Creek rises southwest of Washington, but flows for several miles in the quadrangle. All the streams are tributary to Monongahela River, which is only a few miles distant everywhere east of the quadrangle and nearly touches its southeast corner. The entire quadrangle is covered with a fine network of runs, tributary to the larger streams.

Geologically the streams of the quadrangle represent a mature type of drainage, in which the larger streams have attained a very uniform and gentle slope, and it is only at their heads and on the small feeders scattered over the area that the gradient even approximates to steepness. Few of the streams are likely, therefore, ever to be of much value for power. All except the largest generally run dry or nearly dry in the summer months, and even those which contain water the year round consist of mudholes during the summer. It is probable that with the growth of the communities it will become more and more necessary to construct reservoirs for the storage of water.

USE OF CREEK WATER.

One instance of the use of creek water for mill power is at the Chambers dam, on Bane Creek, $1\frac{3}{4}$ miles above the village of Sunset. At this point the creek water is stored in a pond about a quarter of a mile in length. There is also a small reservoir on a tributary to South Branch of Pigeon Creek, just above the mining town of Three and Four, and one on Center Branch a short distance above the confluence. The construction of many such reservoirs in the region would make it possible to store much of the water that is wasted during the spring and in storms and use it in various ways throughout the year. It is probable that when mining and other operations become more important in the region more such reservoirs will be constructed.

The creeks are now the principal source of water supply of the larger towns.

WATER SUPPLY OF WASHINGTON.

The Washington system of water supply is operated by the Citizens' Water Company, which has four reservoirs in the upper valley of Chartiers Creek, just beyond the quadrangle boundary. It is reported that the company has bought up the watershed, including the Pittsburg coal, with the exception of two or three farms, which are still occupied by their original owners. In all, the company owns 380 acres of land. During the summer months the inhabitants generally complain of a disagreeable "fishy" odor in the water drawn from the faucets, and some have wished to abandon it for this reason. If this odor has the same cause as similar odors which are frequent in surface drinking waters of many towns in the summer, as seems probable, it is due to algæ and similar organisms in the water of the reservoirs. In many towns these have been killed and the water restored to its former pleasant taste by treatment with sulphate of copper. Several years ago a number of cases of typhoid fever broke out in town and were thought by some to have been due to use of city water, but they were more probably due to polluted well water.

The following table gives various statistics concerning the reservoirs:

Statistics of reservoirs at Washington.[a]

	No 1.	No. 2.	No. 3.	No 4.	High-service reservoir.
Area.....acres..	6	3½	30	65	.....
Length.....feet..	750	440	3,000	5,000	[b] 182 [c] 242
Width.....do....	320	320	[d] 700	[d] 1,000	[b] 100 [c] 170
Depth.....do....	6	6	[d] 31	[d] 2	20
Storage capacity.....gallons..	11,000,000	6,000,000	106,000,000	600,000,000	3,700,000
Area of watershed .square miles..	.....	.....	2	4	.....

[a] From memorandum issued by Citizens' Water Company. [b] Bottom. [c] Top. [d] At breast.

The high-service reservoir is situated on the hill southwest of Washington, at an elevation of about 1,330 feet, 309 feet above the pumping station and 293 feet higher than the lowest point in town. The pressure is 70 to 140 pounds. The total storage capacity is 726,700,000 gallons, the capacity of the pump 3,000,000 gallons every twenty-four hours. The consumption in 1902 was less than 1,000,000 gallons per day. It will be seen, therefore, that an abundant supply is assured to Washington for some time.

All water furnished to consumers is first passed through a gravity sand-filter plant. This plant consists of sedimentation and settling tanks and four large automatic sand-filter tanks, which are cleansed every day by machinery. The capacity is between 3,000,000 and 4,000,000 gallons of water per day.

OTHER TOWN SUPPLIES.

The majority of the wells supplying the settlements along Peters Creek and the village of Houston, on Chartiers Creek, are very shallow. In the village of Bentleyville most of the residents have dug wells, but for two or three years a number of drilled wells have been in use. The deepest of these is 240 feet deep, but the majority are only 80 to 90 feet. There are but two springs in use in the village. The supply for the individual houses in the town of Ellsworth is also from wells, the average depth being 100 feet. On a branch of Pigeon Creek, above the Ellsworth collieries Nos. 3 and 4, is situated a small reservoir to supply the coke ovens. This company has lately constructed on the Eli Tombaugh farm, on Center Branch of Pigeon Creek, a reservoir which has an estimated capacity of 12,000,000 gallons, and is, like the other, used to supply water to the plant.

SUPPLY OF THE FARMING COMMUNITIES.

The water supply of the farming communities in this quadrangle comes both from springs and wells. The springs are very numerous, and the topography is such that on the lower slopes of the hills they usually furnish plenty of water. In the valley bottoms and on the flatter ridges and hilltops wells are more common, but in general it is not necessary to go very deep for water. In a number of wells drilled for oil or gas which have failed to produce or run dry, the upper part has been subsequently transformed into a water well and pumped by hand or with a windmill. There are few windmills in the quadrangle, as they are generally unnecessary.

WATER-BEARING HORIZONS.

Few data are at hand regarding water-bearing strata, for the reason that the water wells in this quadrangle are, as a rule, too shallow to permit general interpretations of this nature, and of the oil and gas wells only about twenty record any water horizons.

The principal water-bearing bed recognized by the drillers is the Pottsville formation. For the reason that it contains much salt water, it has been named the "salt sand." By some persons it has on this account been supposed to mark the depth of sea level, but it can be positively stated that the salt sand has no connection with the level of the sea. This sand in eastern Ohio was half a century ago the source of brine for the salt works which formed an important industry at that time. The water generally occurs somewhere near the middle of the salt sand, and may possibly occur in connection with the Mercer member, which in places forms a break in the sand. This supposition is purely hypothetical, however, and it is certainly not everywhere true, as in some cases the water occurs near the top or bottom of the sand.

The deeper oil and gas sands in this region are generally dry or very nearly so, so far as water is concerned, but where water is found at great depths in the wells it is almost uniformly salt. At shallow depths, on the other hand, down to several hundred feet, it is usually fresh. In several cases, notably in the M. Mounts well in North Franklin Township and in the Wherry No. 1 well in West Bethlehem Township, salt water is reported in the "Big Injun" sand of the Pocono formation. In the Mounts well the water filled the well to a depth of 30 feet.

In general, it may be said that there is a possibility of salt water being encountered in any porous oil sand in the synclines. Where oil occurs it is lighter than the water and will rest on it, occurring farther up the flank of the anticline.

Some of the most common occurrences of water are in coal beds.

In the Pittsburg, Upper Freeport, and Kittanning seams, especially, water is often reported. Several other horizons that are locally water-bearing in the Allegheny and Conemaugh are believed to mark portions of coal beds. The J. L. Thompson No. 1 well, in the borough of Deemston, was known to have filled up to the surface, 1,370 feet, from an influx of water somewhere near the base of the Allegheny formation. Water has been found 160 to 175 feet below the Pittsburg coal, 220 feet above the same coal, between the Waynesburg and Washington coals, and nearer the surface, but few shallow horizons are recorded.

TOPOGRAPHIC DATA.

TRIANGULATION STATIONS.

All topographic surveying for the maps of this quadrangle is based on triangulation stations on a number of the principal hilltops of the territory and its vicinity. These stations have been connected by triangulation with stations in other portions of the State and the accuracy of the work carefully checked. The locations of the stations within the quadrangle are shown on the topographic map by small triangles east of Houston, on Mount Wheeler, and at Scenery Hill (Hillsboro), and fig. 7 shows the relative position of all the points. The stations are marked by stone posts, set about 3 feet in the ground, and in the center of the top of each post is cemented a bronze tablet marked, "United States Geological Survey—Pennsylvania."

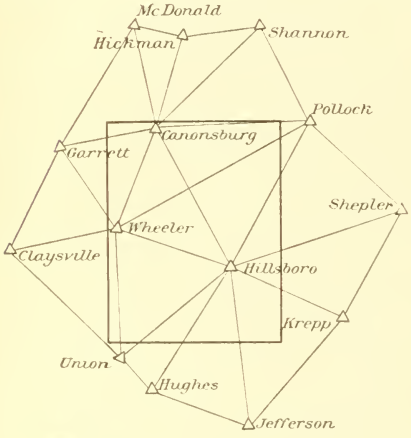


FIG. 7.—Location of triangulation stations in and near the Amity quadrangle.

The following is a description of the stations:

KREPP, WASHINGTON COUNTY.

About 1½ miles northwest of Brownsville, on a prominent and well-known bald knob owned by James Nickson.

[Latitude 40° 01′ 44.55″. Longitude 79° 54′ 25.69″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Hillsboro	115 13 26.6	295 07 06.8	4.1890430

POLLOCK, WASHINGTON COUNTY.

On Pollocks Hill, about 2 miles west of West Elizabeth, on road to Finleyville, 400 feet west of a rough board shanty on highest point of bare hill owned by Mr. McClure.

[Latitude 40° 15′ 08.99″. Longitude 79° 57′ 06.26″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Hillsboro	29	10	08.6	209	05	31.5	4.3197152
Mount Wheeler	61	30	40.4	241	19	25.7	4.4496631
Canonsburg	87	29	40.3	267	20	47.3	4.2904183

JEFFERSON, GREENE COUNTY.

About 1½ miles southeast of Jefferson, on a high bald knob owned by Lawrence Kraft.

[Latitude 39° 54′ 58.46″. Longitude 80° 02′ 11.35″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Hillsboro	171	14	13.9	351	12	54.0	4.2860956

HILLSBORO, WASHINGTON COUNTY.

In a rocky pasture, about 1,000 feet north of Hillsboro (Scenery Hill) church, about halfway between Brownsville and Washington along the National pike, on land owned by Mrs. E. S. Tombaugh, who lives at crossing about 1,500 feet southeast of station.

[Latitude 40° 05′ 17.67″. Longitude 80° 04′ 15.81″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Pollock	209	05	31.5	29	10	08.6	4.3197152
Shepler	251	34	48.6	71	44	42.6	4.3616006
Krepp	295	07	06.8	115	13	26.6	4.1890430
Jefferson	351	12	54.0	171	14	13.9	4.2860956
Keener	319	14	33.3	139	22	16.0	4.4181154
Hughes	33	02	20.9	212	51	42.6	4.2751190
Union	51	48	48.2	231	42	26.5	4.2531028
Mount Wheeler	108	08	43.9	288	02	07.1	4.1859700
Canonsburg	151	42	44.5	331	38	29.5	4.2949237

CANONSBURG, WASHINGTON COUNTY.

In North Strabane Township, in a cultivated field at summit of high knob, 1 mile S. 15° E. of Canonsburg and in view of the town, on land owned by James Hanna, who lives on east side of hill at a road fork.

[Latitude 40° 14′ 40.51″. Longitude 80° 10′ 51.20″.]

To station	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Mount Wheeler	22	31	03.0	202	28	40.8	4.1345757
Claysville	50	18	45.5	230	10	19.6	4.3826975
Garrett	78	04	35.4	257	59	04.1	4.0933003
McDonald	163	11	12.3	343	09	24.7	4.1326119
Hickman	194	34	17.5	14	35	39.2	4.0737263
Shannon	226	14	17.1	46	20	22.0	4.2656474
Pollock	267	20	47.3	87	29	40.3	4.2904183
Hillsboro	331	38	29.5	151	42	44.5	4.2949237

HUGHES, GREENE COUNTY.

On a hill covered with an orchard of small peach trees, about 3½ miles north of Waynesburg, owned by the Hughes estate.

[Latitude 39° 56′ 45.33″. Longitude 80° 11′ 28.53″.]

To station	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Union	141	03	49.6	321	02	06.5	3.7827879
Hillsboro	212	57	42.6	33	02	20.9	4.2751190

M'DONALD, WASHINGTON COUNTY.

In a pasture at the highest point of a hill one-half mile south of McDonald, on land owned by William F. Wood, who lives on the southeast side of hill.

Reference marks: A large black-oak line tree at the north boundary fence 275 feet distant. A large white-oak line tree at the west boundary fence 303 feet distant.

[Latitude 40° 21′ 41.66″. Longitude 89° 13′ 37.56″.]

To station	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Canonsburg	343	09	24.7	163	11	13.3	4.1326119

UNION, GREENE COUNTY.

In a pasture on a prominent hill 7 miles north-northwest of Waynesburg and 1½ miles east of West Union.

[Latitude 39° 59′ 18.24″. Longitude 80° 14′ 19.16″.]

To station	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Wheeler	178	04	16.4	358	04	01.9	4.2002916
Hillsboro	231	42	26.5	51	48	48.2	4.2531028

WHEELER, WASHINGTON COUNTY.

On a sparsely timbered hill 3 miles south of Washington on land of William Courson, who lives at north base of hill.

[Latitude 40° 07′ 52.16″. Longitude 80° 14′ 31.71″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Claysville	78	01	54.2	257	55	51.0	4.1350995
Garrett	145	24	29.4	325	21	20.7	4.0856664
Canonsburg	202	28	40.8	22	31	03.0	4.1345757
Pollock	241	19	25.7	61	30	40.4	4.4496631
Hillsboro	288	02	07.1	108	08	43.9	4.1859700
Union	358	04	01.9	178	04	16.4	4.2002916

GARRETT, WASHINGTON COUNTY.

In a cleared field owned by J. C. Garrett, 3 miles east of Buffalo village and 5 miles northwest of Washington, on the hill road to Hickory.

Reference marks: Wire fence, west 113 feet; large walnut tree, N. 34° 30′ W., 433 feet.

[Latitude 40° 13′ 17.16″. Longitude 80° 19′ 24.18″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Canonsburg	257	59	04.1	178	04	35.4	4.0933003
Mount Wheeler	325	21	20.7	145	24	29.4	4.0856664

CLAYSVILLE, WASHINGTON COUNTY.

On a cone-shaped hill, 1 mile south of Claysville, on cultivated land belonging to J. Mosier.

Reference marks: Double chestnut tree, south 72 feet; apple tree, east 80 feet.

[Latitude 40° 06′ 20.01″. Longitude 80° 23′ 55.46″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Canonsburg	230	10	19.6	50	18	45.5	4.3826975
Mount Wheeler	257	55	51.0	78	01	54.2	4.1350995

SHEPLER, WESTMORELAND COUNTY.

About 4 miles southeast of Bellevernon and 5 miles east of Charleroi, on a high cultivated hill owned by John Shepler.

[Latitude 40° 09′ 12.22″. Longitude 79° 48′ 54.10″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Hillsboro	71 44 42.6	251 34 48.6	4.3616006

SHANNON, ALLEGHENY COUNTY.

About 1 mile south of Castle Shannon post-office, on a high cultivated knob, on which is one tree about 30 feet northeast of signal.

[Latitude 40° 21′ 33.53″. Longitude 80° 01′ 26.95″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Canonsburg	46 20 22.0	226 14 17.1	4.2656474

HICKMAN, ALLEGHENY COUNTY.

On a bald hill in South Fayette Township, 2½ miles southwest of Bridgeville, on land belonging to William Hickman, who lives on south side of hill.

[Latitude 40° 20′ 52.33″. Longitude 80° 08′ 44.87″.]

To station—	Azimuth.	Back azimuth.	Log. distance
	° ′ ″	° ′ ″	*Meters.*
Canonsburg	14 35 39.2	194 34 17.5	4.0737263

MERIDIAN MARKS.

WASHINGTON, WASHINGTON COUNTY.

Location of station: A few feet north of sidewalk, on the south side of and near the southwest corner of the campus of Washington and Jefferson College.

Station mark: A sandstone post 48 by 12 by 12 inches, set about 40 inches in the ground, in the center of top of which is cemented a bronze meridian tablet.

Distant mark: North of station 482 feet; a sandstone post about 48 by 12 by 12 inches, set about 36 inches in the ground, in the center of top of which is cemented a bronze meridian tablet.

SPIRIT-LEVEL DATA.

The contours on the topographic map are based on precise levels run by railroad engineers and by the United States Geological Survey. During the course of the topographic work numerous bench marks were established, and their elevations are given below:

Bench marks in the Amity quadrangle.

	Feet.
Amity, post-office and store of F. F. Iams & Son, on north side of door, east side of road, in stone doorstep of; aluminum tablet marked "1204 PITTSBURG"	1,200.824
Amity, 5.8 miles north of, 180 feet north of crossroads, one to Lone Pine, the other to Amity, on locust tree 10 inches in diameter	1,037.5
Beallsville, 50 feet southwest of center of crossroads at Greenfield's hotel, 30 feet west of corner of porch, in middle of step; bronze tablet marked "1137 PITTSBURG"	1,135.970
Beallsville, 3.3 miles northwest of, at Scenery Hill, at mouth of alley 150 feet north of blacksmith shop, on stone	1,440.34
Centerville, 2 miles northwest of; top of milepost marked "83 miles to Cumberland, 48 miles to Wheeling"	1,206.64
Scenery Hill; Hillsboro triangulation tablet at top of, marked "1467 PITTSBURG"	1,466.858
Scenery Hill, 0.6 mile north of, at bottom of milepost marked "88 to Cumberland, 43 to Wheeling," on stone	1,305.03
Scenery Hill, 1.7 miles north of, at crossroads, 0.75 mile north of pike; oak stump 36 inches in diameter, nail in top of	1,147.87
Vanceville, bridge over Pigeon Creek at, on southeast abutment	1,033.60
Vanceville, 0.5 mile southeast of, 300 feet from top of hill, 300 feet southwest of house, 5 feet west of center of road; oak tree 36 inches in diameter, nail in root of	1,171.46
Vanceville, 0.9 mile northwest of, 400 feet northwest of house, on west side of road; locust tree 24 inches in diameter, nail in root of	1,122.30
Vanceville, 1.7 miles northwest of, bridge over Pigeon Creek, 235 feet south of center of crossroads; bronze tablet, set in north end of southwest abutment, marked "1044 PITTSBURG"	1,042.454
Vanceville, 2.2 miles northwest of, at Dunningsville and Canonsburg crossroads; stone in center of "Y," chisel mark on	1,071.03
Vanceville, 2.3 miles northwest of, 900 feet southwest of church, 35 feet west of bridge, in front of white house, on stone	1,066.11
Venetia, post-office (Anderson station), iron wagon bridge at road crossing, northwest bridge seat of; aluminum tablet stamped "986 PITTSBURG"	985.073
Washington County court-house, 60 feet southeast of southeast corner of, at northwest corner of Cherry alley and Main street, in southeast corner of retaining wall around court-house; bronze tablet marked "1158 PITTSBURG"	1,156.064
Washington, at east end of, 130 feet north of street-car track, at end of paving on National pike, on north side of Baltimore and Ohio Railroad; chisel mark on stone	1,119.85
Washington, 0.4 mile south of, south of Pan Cake at crossroads to Lone Pine and Vance Station, on south side of stone culvert; chisel mark	1,314.6
Washington, 3.1 miles south of, 1.7 miles south of Pan Cake, southeast abutment of bridge over creek; chisel mark	1,084.3
Washington, 3.5 miles east of, railroad bridge No. 153, on northwest corner of abutment; chisel mark	1,112.43
Washington, 7.2 miles east of, railroad bridge No. 144, on southwest abutment, east end; chisel mark	1,005.14
Washington, 7.5 miles east of, Baltimore and Ohio Railroad bridge No. 140, on northwest abutment, on north side of creek, 3 feet below rail; aluminum tablet marked "995 PITTSBURG"	991.754

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INDEX.

Z.

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[Bulletin No. 300.]

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B 293. A reconnaissance of some gold and tin deposits of the southern Appalachians, by L. C. Groton, with notes on the Dahlonega mines, by W. Lindgren. 1906. 134 pp., 9 pls.

B 294. Zinc and lead deposits of the upper Mississippi Valley, by H. Foster Bain. 1906. 155 pp., 16 pls.

B 295. The Yukon-Tanana region, Alaska, description of Circle quadrangle, by L. M. Prindle. 1906. 27 pp., 1 pl.

B 296. Economic geology of the Independence quadrangle, Kansas, by Frank C. Schrader and Erasmus Haworth. 1906. 74 pp., 6 pls.

WS 181. Geology and water resources of Owens Valley, California, by Willis T. Lee. 1906. 28 pp., 6 pls.

B 297. The Yampa coal field, Routt County, Colo., by N. M. Fenneman, Hoyt S. Gale, and M. R. Campbell. 1906. 96 pp., 9 pls.

B 300. Economic geology of the Amity quadrangle in eastern Washington County, Pa., by F. G. Clapp. 1906. 145 pp., 8 pls.

Correspondence should be addressed to

THE DIRECTOR,
UNITED STATES GEOLOGICAL SURVEY,
WASHINGTON, D. C.

FEBRUARY, 1907.

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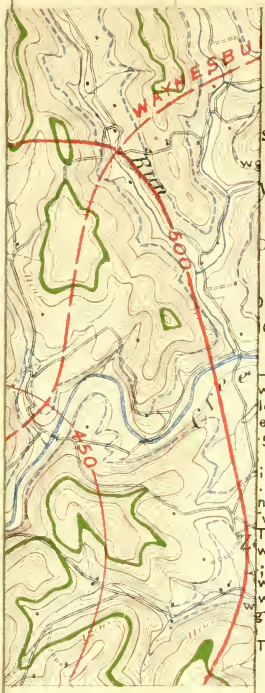

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wells

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oned in the text)

–Numbers 1-13 are in
wp.; 14-16 in Borough
le; 17-18 in Borough of
e; 19-21 in Chartiers
53 in the Borough of
54-55 in East Bethle-
; 56-61 in Morris Twp.,
.; 62-66 in Morris Twp.,
n Co.; 67-71 in North
wp.; 72-119 in North
Twp; 120-122 in Not-
wp.; 123-136 in Somer-
; 137-139 in South
wp.; 140-253 in South
wp; 254-272 in Borough
gton; 273-305 in West
Twp.; 306-309 in West
Twp.

AMITY QU

3

4 5

ECONOMIC GEOLOGY MAP OF THE AMITY QUADRANGLE

H. M. Wilson, Geographer in charge.
Triangulation by D. H. Baldwin.
Topography by Robt. D. Cummin, T. G. Basinger, and A. H. Bumstead.
SURVEYED IN 1901-1902 IN CO-OPERATION WITH THE STATE OF PENNSYLVANIA

Geology by Frederick G. Clapp assisted by Frank W. DeWolf, under the direction of Marius R. Campbell.
SURVEYED IN 1904 IN CO-OPERATION WITH THE STATE OF PENNSYLVANIA

Scale 62500

1 0 1 2 3 4 miles
1 0 1 2 3 4 5 Kilometers

Contour interval 20 feet
Datum is mean sea level

LEGEND

CARBONIFEROUS
Permian (Dunkard)
Pennsylvanian
Monongahela formation 300-360 ft.
Washington formation 280-400 ft.
Greene formation 370+ ft.

Prosperity limestone
Triadelphia coal
Upper Washington limestone
Jollytown limestone
Jollytown coal
Middle Washington limestone
Lower Washington limestone
Washington coal
Waynesburg "A" coal
Waynesburg sandstone
Waynesburg coal
Waynesburg limestone
Uniontown coal
Iveswood limestone
Sewickley coal
Fishpot limestone
Redstone coal
Pittsburg sandstone
Pittsburg coal

pb Pittsburg
wb Waynesburg
wg Washington
rs Redstone
sw Sewickley

Coal outcrops

(solid line show positions of known workable beds; dash lines show positions of probably workable beds; dotted lines represent beds of doubtful workable value)

Structure contours

(showing elevation and "dip" of bottom of the Pittsburg coal bed. Datum is mean sea level)

Oil fields

(only those wells are shown of which the records are published in this report)

Outcrop of upper Washington limestone

- Coal mines
- Country coal banks
- Abandoned banks or prospects
- Abandoned mines
- Limestone quarries
- Sandstone quarries
- Shale pits
- Oil wells
- Gas wells
- Dry holes
- Product not known

(Numbers refer to wells mentioned in the text)

NOTE.—Numbers 1-13 are in Amwell Twp.; 14-16 in Borough of Beallsville; 17-18 in Borough of Bentleyville; 19-21 in Chartiers Twp.; 22-53 in the Borough of Deemston; 54-55 in East Bethlehem Twp.; 56-61 in Morris Twp.; Greene Co.; 62-68 in Morris Twp., Washington Co.; 69-71 in North Franklin Twp.; 72-119 in North Strabane Twp.; 120-183 in Nottingham Twp.; 133-136 in Somerset Twp.; 137-169 in South Franklin Twp.; 149-253 in South Strabane Twp.; 254-272 in Borough of Washington; 273-305 in West Bethlehem Twp.; 306-309 in West Pike Run Twp.